

ASTRONOMY

DECEMBER 1974

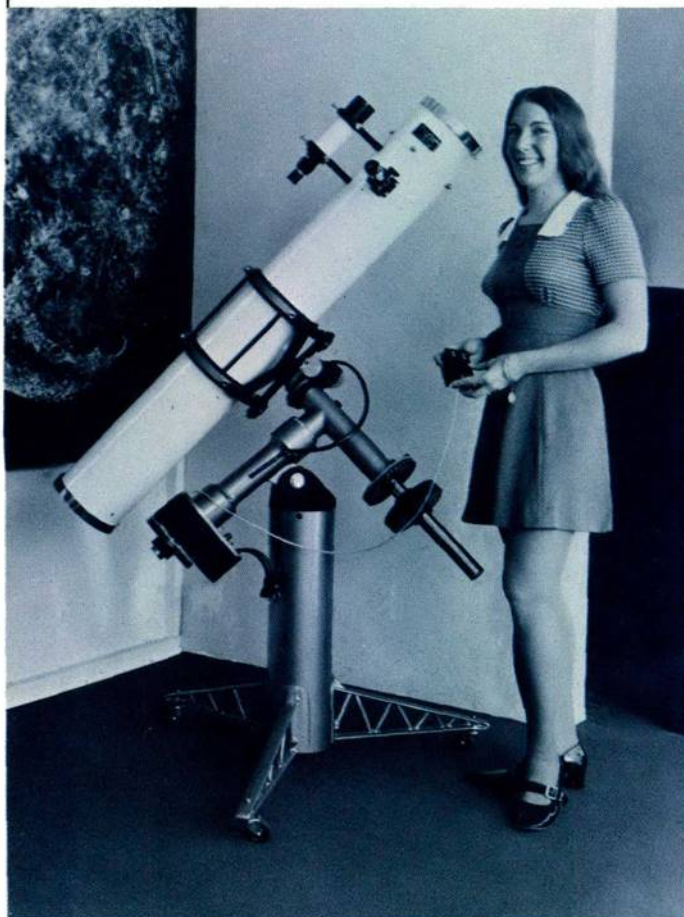
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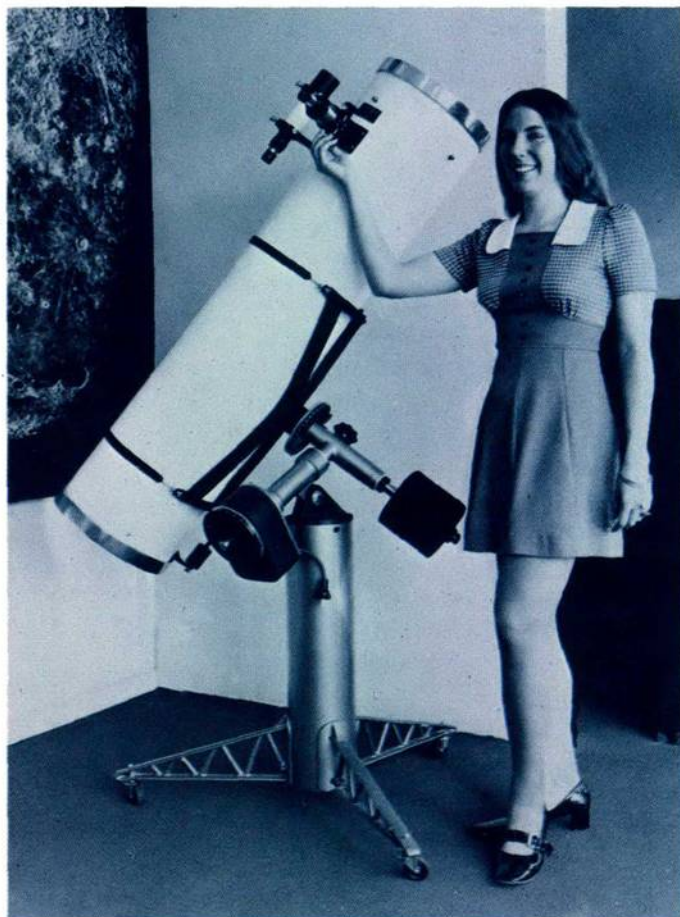
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Cover

Artwork by Adolf Schaller

Night on a small planet within one of the Perseus double clusters is a kaleidoscope of stellar beauty. Dozens of stars brighter than Venus — some of them red supergiants of tremendous brilliance — give the landscape an eerie glow. Less than 1,000 light-years away the companion cluster forms a celestial jewel box to the upper left in this rendering. Hints for locating and observing the double cluster — an easy naked eye object — are given in this month's Constellation Close-Up. The telescopic appearance of the cluster is illustrated on page 46.

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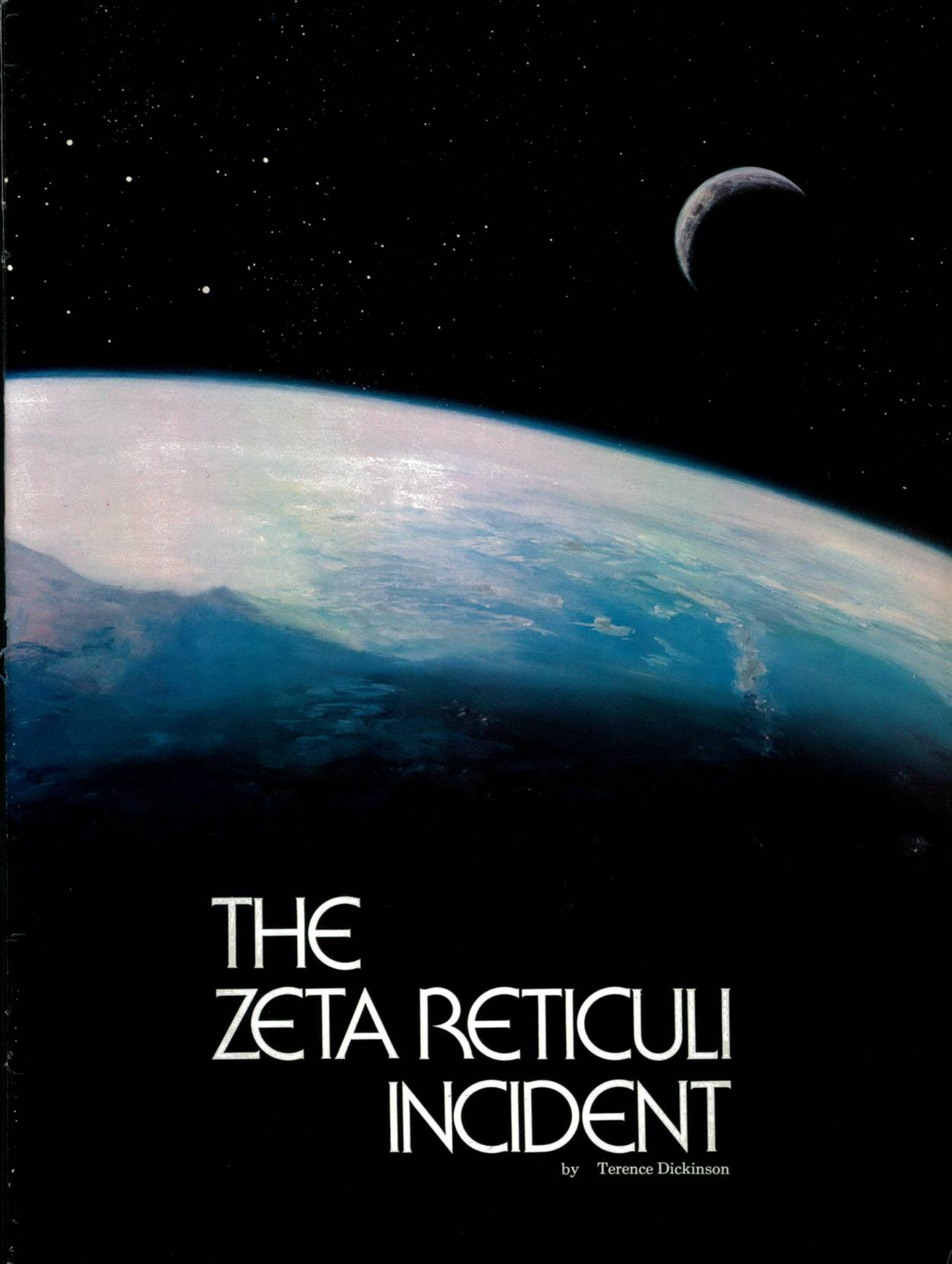
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A detailed painting of Earth from space, showing the curvature of the planet with a blue atmosphere and white clouds. A thin crescent moon is visible in the upper right against a starry black sky. The title text is overlaid on the lower portion of the image.

THE ZETA RETICULI INCIDENT

by Terence Dickinson

A faint pair of stars, 220 trillion miles away, has been tentatively identified as the "home base" of intelligent extraterrestrials who allegedly visited Earth in 1961. This hypothesis is based on a strange, almost bizarre series of events mixing astronomical research with hypnosis, amnesia, and alien humanoid creatures.

The two stars are known as Zeta 1 and Zeta 2 Reticuli, or together as simply Zeta Reticuli. They are each fifth magnitude stars — barely visible to the unaided eye — located in the obscure southern constellation Reticulum. This southerly sky location makes Zeta Reticuli invisible to observers north of Mexico City's latitude.

The weird circumstances that we have dubbed "The Zeta Reticuli Incident" sound like they come straight from the UFO pages in one of those tabloids sold in every supermarket. But this is much more than a retelling of a famous UFO incident; it's an astronomical detective story that at times hovers on that hazy line that separates science from fiction. It all started this way:

The date is Sept. 19, 1961. A middle aged New Hampshire couple, Betty and Barney Hill, are driving home from a short vacation in Canada. It's dark, with the moon and stars illuminating the wooded landscape along U. S. Route 3 in central New Hampshire. The Hills' curiosity is aroused when a bright "star" seems to move in an irregular pattern. They stop the car for a better view. The object moves closer, and its disklike shape becomes evident.

Barney grabs his binoculars from the car seat and steps out. He walks into a field to get a closer look, focuses the binoculars, and sees the object plainly. It has windows — and behind the windows, looking directly at him are... humanoid creatures! Terrified, Barney stumbles back to the car, throws it into first gear and roars off. But for some reason he turns down a side road where five of the humanoids are standing on the road.

Apparently unable to control their actions, Betty and Barney are easily taken back to the ship by the humanoids. While inside they are physi-

cally examined, and one of the humanoids communicates to Betty. After the examination she asks him where they are from. In response he shows her a three-dimensional map with various sized dots and lines on it. "Where are you on the map?" the humanoid asks Betty. She doesn't know, so the subject is dropped.

Betty and Barney are returned unharmed to their car. They are told they will forget the abduction portion of the incident. The ship rises, and then hurtles out of sight. The couple continue their journey home oblivious of the abduction.

But the Hills are troubled by unexplained dreams and anxiety about two hours of their trip that they can't account for. Betty, a social worker, asks advice from a psychiatrist friend. He suggests that the memory of that time will be gradually restored over the next few months — but it never is. Two years after the incident, the couple are still bothered by the missing two hours, and Barney's ulcers are acting up. A Boston psychiatrist, Benjamin Simon, is recommended, and after several months of weekly hypnosis sessions the bizarre events of that night in 1961 are revealed. A short time later a UFO group leaks a distorted version of the story to the press and the whole thing blows up. The Hills reluctantly disclose the entire story.

Can we take this dramatic scenario seriously? Did this incredible contact with aliens actually occur or is it some kind of hallucination that affected both Barney and Betty Hill? The complete account of the psychiatric examination from which the details of the event emerged is related in John G. Fuller's **The Interrupted Journey** (Dial Press, 1966); where we read that after the extensive psychiatric examination, Simon concluded that the Hills were not fabricating the story. The most likely possibilities seem to be: (a) the experience actually happened, or (b) some perceptive and illusory misinterpretations occurred in relationship to some real event.

There are other cases of alleged abductions by extraterrestrial humanoids. The unique aspect of the Hills' abduction is that they remembered virtually nothing of the incident.

Intrigued by the Hills' experience, J. Allen Hynek, chairman of the department of astronomy at Northwestern University, decided to investigate. Hynek described how the Hills recalled the details of their encounter in his book, **The UFO Experience** (Henry Regnery Company, 1972):

"Under repeated hypnosis they independently revealed what had supposedly happened. The two stories agreed in considerable detail, although neither Betty nor Barney was privy to what the other had said under hypnosis until

A nuclear-pulse powered starship begins a historic voyage to some nearby stars similar to our sun sometime in the 21st century. The first target is Tau Ceti, 12 light-years distant and seen in this rendering just to the right of the craft's spherical living quarters. This article chronicles how an unusual star map has led to new investigations of specific nearby stars that might harbor Earthlike planets — and possibly advanced forms of life.

Artwork by John Clark

much later. Under hypnosis they stated that they had been taken separately aboard the craft, treated well by the occupants — rather as humans might treat experimental animals — and then released after having been given the hypnotic suggestion that they would remember nothing of that particular experience. The method of their release supposedly accounted for the amnesia, which was apparently broken only by counterhypnosis.”

A number of scientists, including Hynek, have discussed this incident at length with Barney and Betty Hill and have questioned them under hypnosis. They concur with Simon’s belief that there seems to be no evidence of outright fabrication or lying. One would also wonder what Betty, who has a master’s degree in social work and is a supervisor in the New Hampshire Welfare Department, and Barney, who was on the governor of New Hampshire’s Civil Rights Commission, would have to gain by a hoax? Although the Hills didn’t, several people have lost their jobs after being associated with similarly unusual publicity.

Stanton T. Friedman, a nuclear physicist and the nation’s only space scientist devoting full time to researching the UFO phenomenon, has spent many hours in conversation with the Hills. “By no stretch of the imagination could anyone who knows them conclude that they were nuts,” he emphasizes.

So the experience remains a fascinating story despite the absence of proof that it actually happened. Anyway — that’s where things were in 1966 when Marjorie Fish, an Ohio schoolteacher, amateur astronomer and member of Mensa, became involved. She wondered if the objects shown on the map that Betty Hill allegedly observed inside the vehicle might represent some actual pattern of celestial objects. To get more information about the map she decided to visit Betty Hill in the summer of 1969. (Barney Hill died in early 1969.) Here is Ms. Fish’s account of that meeting:

“On Aug. 4, 1969, Betty Hill discussed the star map with me. Betty explained that she drew the map in 1964 under posthypnotic suggestion. It was to be drawn only if she could remember it accurately, and she was not to pay attention to what she was drawing — which puts it in the realm of automatic drawing. This is a way of getting at repressed or forgotten material and can result in unusual accuracy. She made two erasures showing her conscious mind took control part of the time.

“Betty described the map as three-dimensional, like looking through a window. The stars were tinted and glowed. The map material was flat and thin (not a model), and there were no noticeable lenticular lines like one of our three-

Hill Map



Fish Interpretation



Computer Generated Map



Three key phases in the analysis described in this article are illustrated here. Top diagram is a copy of the map Betty Hill drew, allegedly a duplicate of one she saw inside an extraterrestrial vehicle. Center map is derived from a model of our stellar neighborhood by Marjorie Fish. It shows the stars that coincide with those on the Hill map (the Fish model is illustrated on page 14). The only area of significant incongruity is the wide separation of Zeta Reticuli in the Hill version. Lower photo shows a cathode ray tube computer readout that was run at Ohio State University as a check on the Fish model. Data used to derive the Fish model and the computer readout were taken from Gliese catalog. Names of specific stars are given on pages 12 and 13.



Artwork by Don Dixon

Advanced life on this planet was annihilated when its sun ended its "normal" phase as a main sequence star and ballooned into the red giant seen here. This change, which

vastly increases a star's energy output, can occur at various times depending on the star's mass. It won't happen to the sun for six billion years.

dimensional processes. (It sounds very much like a reflective hologram.) Betty did not shift her position while viewing it, so we cannot tell if it would give the same three-dimensional view from all positions or if it would be completely three-dimensional. Betty estimated the map was approximately three feet wide and two feet high with the pattern covering most of the map. She was standing about three feet away from it. She said there were many other stars on the map but she only (apparently) was able to specifically recall the prominent ones connected by lines and a small distinctive triangle off to the left. There was no concentration of stars to indicate the Milky Way (galactic plane) suggesting that if it represented reality, it probably only contained local stars. There were no grid lines."

So much for the background material on the Hill incident. (If you want more details on the encounter, see Fuller's book). For the moment we will leave Marjorie Fish back in 1969 trying to interpret Betty Hill's reproduction of the map. There is a second major area of background information that we have to attend to before we can properly discuss the map. Unlike the bizarre events just described, the rest is pure astronomy.

According to the most recent star catalogs, there are about 1,000 known stars within a radius of 55 light-years of the sun.

What are those other stars like? A check of the catalogs shows that most of them are faint stars of relatively low temperature — a class

of stars astronomers call *main sequence* stars. The sun is a main sequence star along with most of the other stars in this part of the Milky Way galaxy, as the following table shows:

Main sequence stars	91%
White dwarfs	8%
Giants and Supergiants	1%

Typical giant stars are Arcturus and Capella. Antares and Betelgeuse are members of the ultrarare supergiant class. At the other end of the size and brightness scale the white dwarfs are stellar cinders — the remains of once brilliant suns. For reasons that will soon become clear we can remove these classes of stars from our discussion and concentrate on the main sequence stars.

The main sequence stars can be further subdivided.

MAIN SEQUENCE STARS

Spectral Class	Proportion of Total	Examples
A	1%	Vega
F	3%	Procyon
G	9%	Sun
K	14%	Epsilon Eridani
M	73%	Proxima Centauri

The spectral class letters are part of a system of stellar "fingerprinting" that identifies the main sequence star's temperature and gives clues

to its mass and luminosity. The hottest, brightest and most massive main sequence stars (with rare exceptions) are the A stars. The faintest, coolest and least massive are the M stars.

Each class is subdivided into 10 subcategories. For example, an A0 star is hotter, brighter and more massive than an A1 which is above an A2, and so on through A9. There's another table below to show what we mean.

This table supplies much additional information and shows how a slightly hotter and more massive star turns out to be much more luminous than the sun, a G2 star. But the bright stars pay dearly for their splendor. It takes a lot of stellar fuel to emit vast quantities of light and heat. The penalty is a short lifespan as a main sequence star. Conversely, the inconspicuous, cool M stars may be around to see the end of the universe — whatever that might be. With all these facts at hand we're now ready to tackle the first part of the detective story.

Let's suppose we wanted to make our own map of a trip to the stars. We will limit ourselves to the 55 light-year radius covered by the detailed star catalogs. The purpose of the trip will be to search for intelligent life on planets that may be in orbit around these stars. We would want to include every star that would seem likely to have a life-bearing planet orbiting around it. How many of these thousand-odd stars would we include for such a voyage and which direction would we go? (For the moment, we'll forget about the problem of making a spacecraft that will take us to these stars and we'll assume that we've got some kind of vehicle that will effortlessly transport us to wherever we want to go.) We don't want to waste our time and efforts — we only want to go to stars that we would think would have a high probability of having planets harboring advanced life forms. This seems like a tall order. How do we

even begin to determine which stars might likely have such planets?

The first rule will be to restrict ourselves to life as we know it, the kind of life that we are familiar with here on Earth — carbon based life. Science fiction writers are fond of describing life forms based on chemical systems that we have been unable to duplicate here on Earth — such as silicon based life or life based on the ammonium hydroxide molecule instead of on carbon. But right now these life forms are simply fantasy — we have no evidence that they are in fact possible. Because we don't even know what they might look like — if they're out there — we necessarily have to limit our search to the kind of life that we understand.

Our kind of life — life as we know it — seems most likely to evolve on a planet that has a stable temperature regime. It must be at the appropriate distance from its sun so that water is neither frozen nor boiled away. The planet has to be the appropriate size so that its gravity doesn't hold on to too much atmosphere (like Jupiter) or too little (like Mars). But the main ingredient in a life-bearing planet is its star. And its star is the only thing we can study since planets of other stars are far too faint to detect directly.

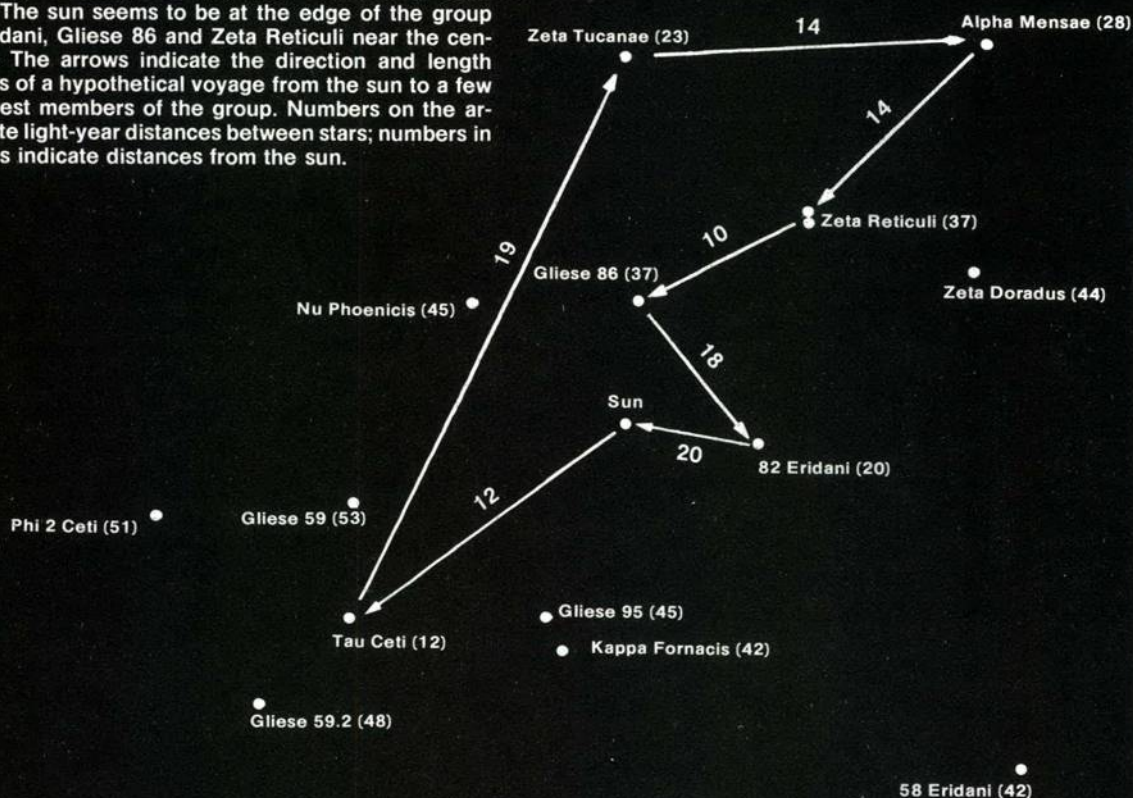
The conclusion we can draw is this: The star has to be like the sun.

Main sequence stars are basically like the sun but differ in small, but important ways. Our last table indicated the sun (a G2 star) has a stable lifespan of about 11 billion years. We are about five billion years into that period so we can look forward to the sun remaining much as it is (actually it will brighten slightly) for another six billion years. Stars of class F4 or higher have stable burning periods of less than 3.5 billion years. They have to be ruled out immediately.

CHARACTERISTICS OF MAIN SEQUENCE STARS

Class	Temperature (degrees Fahrenheit)	Mass (sun=1)	Luminosity (sun=1)	Lifespan (billions of years)
A0	20,000	2.8	60	0.5
A5	15,000	2.2	20	1.0
F0	13,000	1.7	6	2.0
F5	12,000	1.25	3	4.0
G0	11,000	1.06	1.3	10
G5	10,000	0.92	0.8	15
K0	9,000	0.80	0.4	20
K5	8,000	0.69	0.1	30
M0	7,000	0.48	0.02	75
M5	5,000	0.20	0.001	200

Sixteen stars, including the sun, form a cluster of solar type stars. The sun seems to be at the edge of the group with 82 Eridani, Gliese 86 and Zeta Reticuli near the central region. The arrows indicate the direction and length of segments of a hypothetical voyage from the sun to a few of the nearest members of the group. Numbers on the arrows indicate light-year distances between stars; numbers in parentheses indicate distances from the sun.



Such stars cannot have life-bearing planets because, at least based on our experience on our world, this is not enough time to permit highly developed biological systems to evolve on the land areas of a planet. (Intelligent life may very well arise earlier in water environments, but let's forget that possibility since we have not yet had meaningful communication with the dolphins — highly intelligent creatures on this planet!) But we may be wrong in our estimate of life development time. There is another more compelling reason for eliminating stars of class F4 and brighter.

So far, we have assumed all stars have planets, just as our sun does. Yet spectroscopic studies of stars of class F4 and brighter reveal that most of them are in fact unlike our sun in a vital way — they are rapidly rotating stars. The sun rotates once in just under a month, but 60 percent of the stars in the F0 to F4 range rotate much faster. And almost all A stars are rapid rotators too. It seems, from recent studies of stellar evolution that slowly rotating stars like the sun rotate slowly *because* they have planets. Apparently the formation of a planetary system robs the star of much of its rotational momentum.

For two reasons, then, we eliminate stars of class F4 and above: (1) most of them rotate rapidly and thus seem to be planetless, and (2)

their stable lifespans are too brief for advanced life to develop.

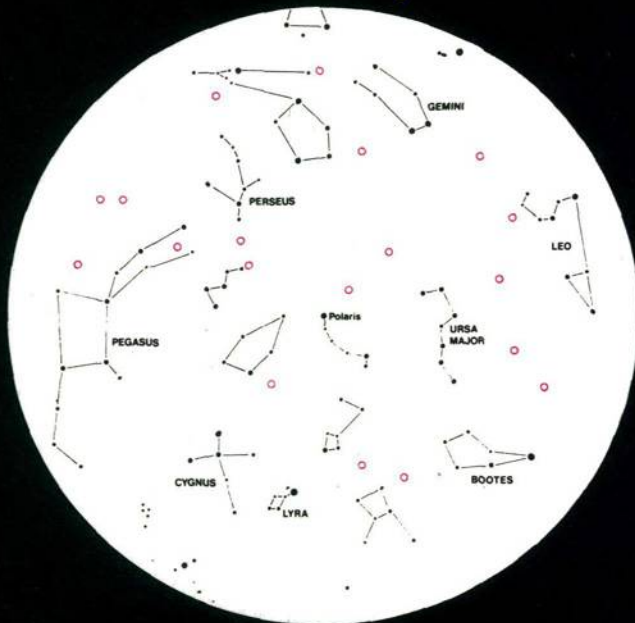
Another problem environment for higher forms of life is the multiple star system. About half of all stars are born in pairs, or small groups of three or more. Our sun could have been part of a double star system. If Jupiter was 80 times more massive it would be an M6 red dwarf star. If the stars of a double system are far enough apart there is no real problem for planets sustaining life (see "Planet of the Double Sun", September 1974). But stars in fairly close or highly elliptical orbits would alternately fry or freeze their planets. Such planets would also likely have unstable orbits. Because this is a potentially troublesome area for our objective, we will eliminate all close and moderately close pairs or systems of multiple stars.

Further elimination is necessary according to the catalogs. Some otherwise perfect stars are labeled "variable". This means astronomers have observed variations of at least a few percent in the star's light output. A one percent fluctuation in the sun would be annoying for us here on Earth. Anything greater would cause climatic disaster. Could intelligent life evolve under such conditions, given an otherwise habitable planet? It seems unlikely. We are forced to "scratch" all stars suspected or proven to be variable.

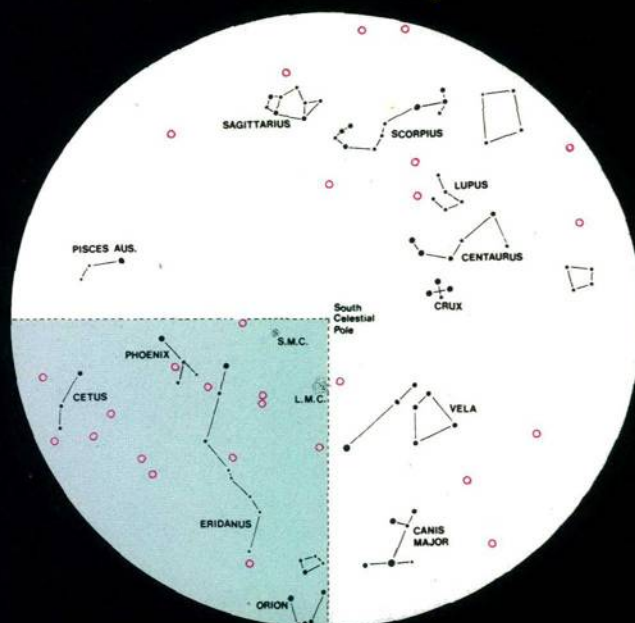
This still leaves a few F stars, quite a few G

Location of Solar-type Stars

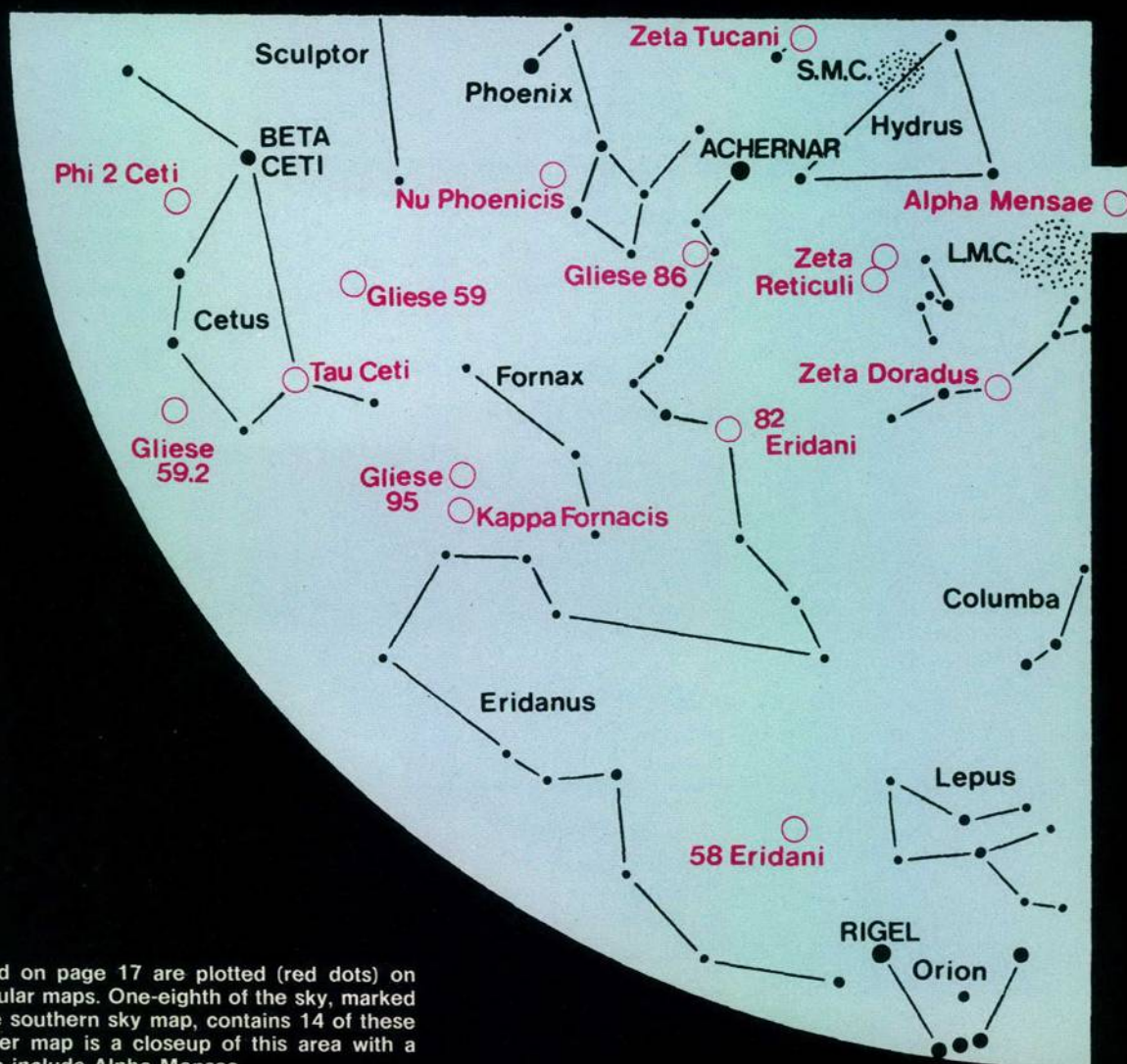
Northern Sky



Southern Sky



Detail of Quadrant from Southern Sky



All the stars listed on page 17 are plotted (red dots) on the two small circular maps. One-eighth of the sky, marked by a wedge in the southern sky map, contains 14 of these 46 stars. The lower map is a closeup of this area with a slight extension to include Alpha Mensae.

Diagrams by Victor Costanzo

stars, and hoards of K and M dwarfs. Unfortunately most of the Ks and all of the Ms are out. Let's find out why.

These stars quite likely have planets. Indeed, one M star — known as Barnard's star — is believed to almost certainly have at least one, and probably two or three, Jupiter sized planets. Peter Van de Kamp of the Sproul Observatory at Swarthmore College (Pa.) has watched Barnard's star for over three decades and is convinced that a "wobbling" motion of that star is due to perturbations (gravitational "pulling and pushing") caused by its unseen planets. (Earth sized planets cannot be detected in this manner.)

But the planets of M stars and the K stars below K4 have two serious handicaps that virtually eliminate them from being abodes for life. First, these stars fry their planets with occasional lethal bursts of radiation emitted from erupting solar flares. The flares have the same intensity as those of our sun, but when you put that type of flare on a little star it spells disaster for a planet that is within, say, 30 million miles. The problem is that planets have to be that close to get enough heat from these feeble suns. If they are farther out, they have frozen oceans and no life.

The close-in orbits of potential Earthlike planets of M and faint K stars produce the second dilemma — rotational lock. An example of rotational lock is right next door to us. The moon, because of its nearness to Earth, is strongly affected by our planet's tidal forces. Long ago our satellite stopped rotating and now has one side permanently turned toward Earth. The same principles apply to planets of small stars that would otherwise be at the right distance for moderate temperatures. If rotational lock has not yet set in, at least rotational retardation would make impossibly long days and nights (as evidenced by Mercury in our solar system).

What stars are left after all this pruning? All of the G stars remain along with F5 through F9 and K0 through K4. Stephen Dole of the Rand Corporation has made a detailed study of stars in this range and suggests we should also eliminate F5, F6 and F7 stars because they balloon to red giants before they reach an age of five billion years. Dole feels this is cutting it too fine for intelligent species to fully evolve. Admittedly this is based on our one example of intelligent life — us. But limited though this parameter is, it is the only one we have. Dole believes the K2, K3 and K4 stars are also poor prospects because of their feeble energy output and consequently limited zone for suitable Earthlike planets.

Accepting Dole's further trimming we are left with single, nonvariable stars from F8 through all the Gs to K1. What does that leave us with? Forty-six stars (they are tabulated on page 17).

Now we are ready to plan the trip. It's pretty obvious that Tau Ceti is our first target. After that, the choice is more difficult. We can't take each star in order or we would be darting all over the sky. It's something like planning a vacation trip. Let's say we start from St. Louis and want to hit all the major cities within a 1,000 mile radius. If we go west, all we can visit is Kansas City and Denver. But northeast is a bonanza: Chicago, Detroit, Cleveland, Pittsburgh, Philadelphia, New York and more. The same principle applies to the planning of our interstellar exploration. The plot (page 11) of all 46 candidate stars reveals a clumping in the direction of the constellations Cetus and Eridanus. Although this section amounts to only 13 percent of the entire sky, it contains 15 of the 46 stars, or 33 percent of the total. The section of the sky that includes this area is shown in more detail on page 11. Luckily Tau Ceti is in this group, so that's the direction we should go (comparable to heading



northeast from St. Louis). If we plan to visit some of these solar type stars and then return to Earth, we should try to have the shortest distance between stops. It would be a waste of exploration time if we zipped randomly from one star to another.

The route map on page 10 shows the culmination of our efforts. This group of stars is a "natural" for exploration when we achieve interstellar flight. Even if, as most exobiologists contend, we are highly unlikely to find advanced forms of life in such a small sample, the physical exploration of planets of other stars by beings from Earth is inevitable, and the stars of this group should be among the first targets.

Now we are ready to return to the map drawn by Betty Hill. Marjorie Fish reasoned that if the stars in the Hill map corresponded to a pattern of real stars — perhaps something like we just developed, only from an alien's viewpoint — it might be possible to pinpoint the origin of the

alleged space travelers. Assuming the two stars in the foreground of the Hill map were the "base" stars (the sun, a single star, was ruled out here), she decided to try to locate the entire pattern. She theorized that the Hill map contained only local stars since no concentration of stars was evident. Such a concentration would be present if a more distant viewpoint was assumed and if both "us" and the alien visitors' home base were to be represented.

Let's assume, just as an *astronomical exercise*, that the map *does* show the sun and the star that is "the sun" to the humanoids. We'll take the Hill encounter at face value, and see where it leads.

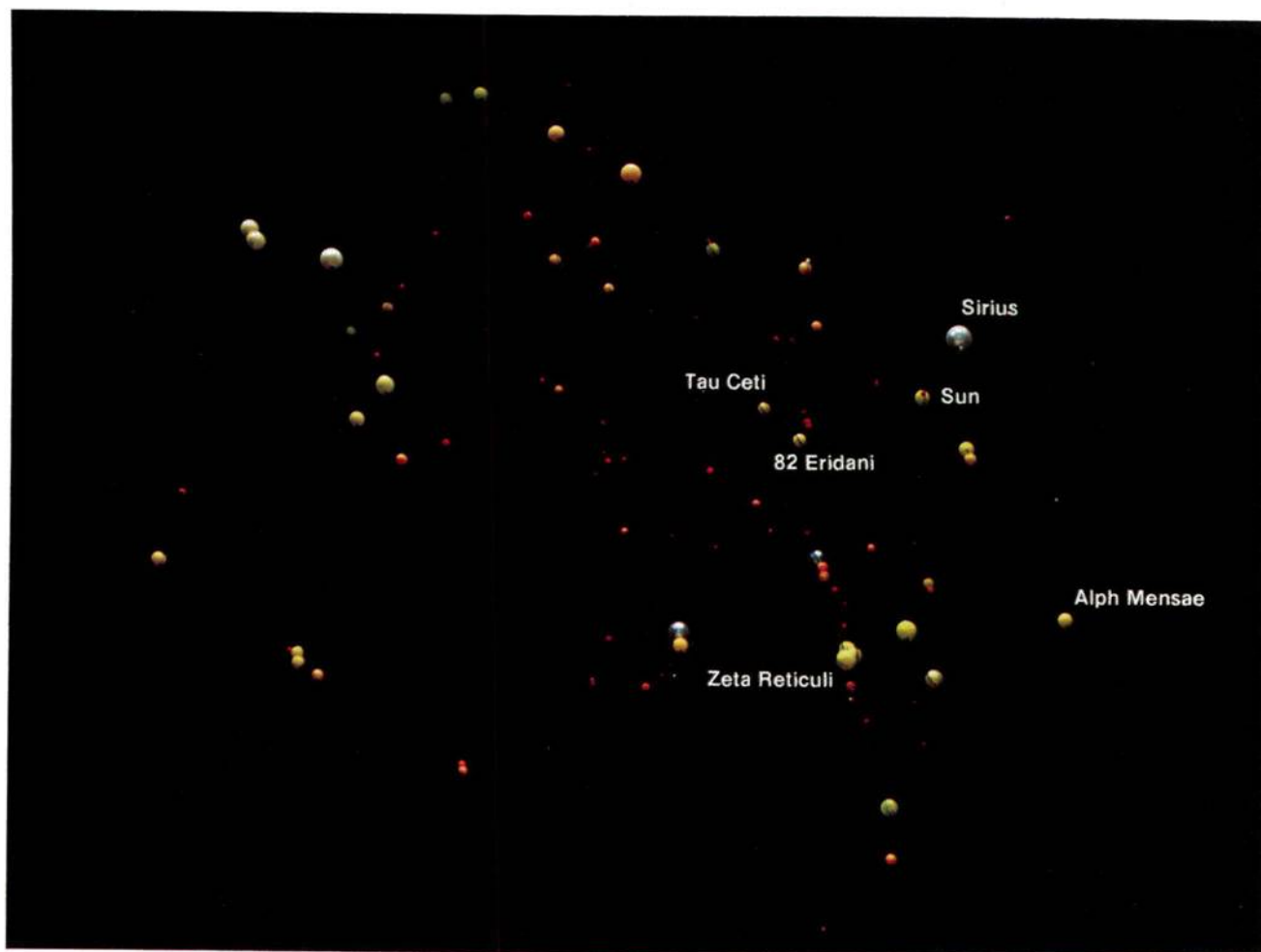
Since the aliens were described as "humanoid" and seemed reasonably comfortable on this planet, their home planet should be basically like ours. Their atmosphere must be similar because the Hills breathed without trouble while inside the ship, and the aliens did not appear to wear any protective apparatus. And since we assume their biology is similar to ours, their planet should have the same temperature regime as Earth (Betty and Barney did say it was uncomfortably cold in the ship). In essence, then, we assume their home planet must be very Earthlike. Based on what we discussed earlier it follows that their sun would be on our list if it were within 55 light-years of us.

The lines on the map, according to Betty Hill, were described by the alien as "trade routes" or "places visited occasionally" with the dotted lines as "expeditions". Any interpretation of the Betty Hill map must retain the logic of these routes (i.e. the lines would link stars that would be worth visiting).

Keeping all this in mind, Marjorie Fish constructed several three-dimensional models of the solar neighborhood in hopes of detecting the pattern in the Hill map. Using beads dangling on threads, she painstakingly recreated our stellar environment. Between Aug. 1968 and Feb. 1973, she strung beads, checked data, searched and checked again. A suspicious alignment, detected in late 1968, turned out to be almost a perfect match once new data from the detailed 1969 edition of the **Catalog of Nearby Stars** became available. (This catalog is often called the "Gliese catalog" — pronounced "glee-see" — after its principal author, Wilhelm Gliese.)

The 16 stars in the stellar configuration discovered by Marjorie Fish are compared with the map drawn by Betty Hill in the diagram on page 7. If some of the star names on the Fish map sound familiar, they should. Ten of the 16 stars are from the compact group that we selected earlier based on the most logical direction to pursue to conduct interstellar exploration from Earth.





This model, prepared by Marjorie Fish, shows all the stars located in a vast volume of space extending out about 55 light-years in the direction of Zeta Reticuli. The viewing angle is from a point in space beyond that limit looking back toward the sun. Each star is suspended on a separate thread at its appropriate distance and position from the sun, and colored according to its spectral type (solar type stars are yellow). The star "behind"

the two components of Zeta Reticuli is Zeta Tucanae. From a model such as this, using the same viewing angle seen here, Marjorie Fish noted 16 stars whose positions are remarkably close to the stars in the drawing made by Betty Hill. The fact that all the stars in the "Hill configuration" are solar type stars is one of several intriguing areas that enshroud the "Zeta Reticuli Incident".

Continuing to take the Hill map at face value, the radiating pattern of "trade routes" implies that Zeta 1 and Zeta 2 Reticuli are the "hub" of exploration or, in the context of the incident, the aliens' home base. The sun is at the end of one of the supposedly regular trade routes.

The pair of stars that make up Zeta Reticuli is practically in the midst of the cluster of solar type stars that attracted us while we were mapping out a logical interstellar voyage. Checking further we find that all but two of the stars in the Fish pattern are on the table of nearby solar type stars. These two stars are Tau 1 Eridani (an F6 star) and Gliese 86.1 (K2), and are, respectively, just above and below the parameters we arrived at earlier. One star that should be there (Zeta Tucanae) is missing probably because it is behind Zeta 1 Reticuli at the required viewing angle.

To summarize, then: (1) the pattern dis-

covered by Marjorie Fish has an uncanny resemblance to the map drawn by Betty Hill; (2) the stars are mostly the ones that we would visit if we were exploring from Zeta Reticuli, and (3) the travel patterns generally make sense.

Walter Mitchell, professor of astronomy at Ohio State University in Columbus, has looked at Marjorie Fish's interpretation of the Betty Hill map in detail and tells us, "The more I examine it, the more I am impressed by the astronomy involved in Marjorie Fish's work."

During their examination of the map, Mitchell and some of his students inserted the positions of hundreds of nearby stars into a computer and had various space vistas brought up on a cathode ray tube readout. They requested the computer to put them in a position out beyond Zeta Reticuli looking toward the sun. From this viewpoint the map pattern obtained by Marjorie Fish was duplicated with virtually no variations. Mitchell noted an important and previously un-

known fact first pointed out by Ms. Fish: The stars in the map are almost in a plane; that is, they fill a wheel shaped volume of space that makes star hopping from one to another easy and the logical way to go — and that is what is implied by the map that Betty Hill allegedly saw.

"I can find no major point of quibble with Marjorie Fish's interpretation of the Betty Hill map," says David R. Saunders, a statistics expert at the Industrial Relations Center of the University of Chicago. By various lines of statistical

reasoning he concludes that the chances of finding a match among 16 stars of a specific spectral type among the thousand-odd stars nearest the sun is "at least 1,000 to 1 against".

"The odds are about 10,000 to 1 against a random configuration matching perfectly with Betty Hill's map," Saunders reports. "But the star group identified by Marjorie Fish isn't quite a perfect match, and the odds consequently reduce to about 1,000 to 1. That is, there is one chance in 1,000 that the observed degree of con-

The View From Zeta Reticuli

The two stars that comprise the Zeta Reticuli system are almost identical to the sun. They are the only known examples of two solar type stars apparently linked into a binary star system of wide separation.

Zeta 1 is separated from Zeta 2 by at least 350 billion miles — about 100 times the sun-Pluto distance. They may be even farther apart, but the available observations suggest they are moving through space together and are therefore physically associated. They probably require at least 100,000 years to orbit around their common center of gravity.

Both Zeta 1 and Zeta 2 are prime candidates for the search for life beyond Earth. According to our current theories of planetary formation, they both should have a retinue of planets something like our solar system. As yet there is no way of determining if any of the probable planets of either star is similar to Earth.

To help visualize the Zeta Reticuli system, let's take the sun's nine planets and put them in identical orbits around Zeta 2. From a celestial mechanics standpoint there is no reason why this situation could not exist. Would anything be different? Because of Zeta 2's slightly smaller mass as compared with the sun, the planets would orbit a little more slowly. Our years might have 390 days, for example. Zeta 2 would make a fine sun — slightly dimmer than "old Sol", but certainly capable of sustaining life. The big difference would not be our new sun but the superstar of the night sky. Shining like a polished gem, Zeta 1 would be the dazzling highlight of the night sky — unlike anything we experience here on Earth. At magnitude -9 it would appear as a starlike point 100 times brighter than Venus. It would be like compressing all the light from the first quarter moon into a point source.

Zeta 1 would have long ago been the focus of religions, mythology and astrology if it were in earthly skies. The fact that it would be easily visible in full daylight would give Zeta 1 supreme importance to both early civilizations and modern man. Shortly after the invention of the telescope astronomers would be able to detect Jupiter and Saturn sized planets orbiting around Zeta 1. Jupiter would be magnitude +12, visible up to 4.5 minutes of arc from Zeta 1 (almost as far as Ganymede swings from Jupiter). It would not make a difficult target for an eight inch telescope. Think of the incentive *that* discovery would have on interstellar space travel! For hundreds of years we would be aware of another solar system just a few "light-weeks" away. The evolution of interstellar spaceflight would be rapid, dynamic and inevitable.

By contrast, our nearest solar type neighbor is Tau Ceti at 12 light-years. Even today we only suspect it is accompanied by a family of planets, but we don't know for sure.

From this comparison of our planetary system with those of Zeta Reticuli, it is clear that any emerging technologically advanced intelligent life would probably have great incentive to achieve star flight. The knowledge of a nearby system of planets of a solar type star would be compelling — at least it would certainly seem to be.

What is so strange — and this question prompted us to prepare this article — is: Why, of all stars, does Zeta Reticuli seem to fit as the hub of a map that appeared inside a spacecraft that allegedly landed on Earth in 1961? Some of the circumstances surrounding the whole incident are certainly bizarre, but not everything can be written off as coincidence or hallucination. It may be optimistic, on one extreme, to hope that our neighbors are as near as 37 light-years away. For the moment we will be satisfied with considering it an exciting possibility. 



Harvard Observatory Photograph

Zeta Reticuli is a close pair of faint fifth magnitude naked eye stars in the constellation Reticulum — itself composed of stars fainter than third magnitude. A nest of about a dozen nearby stars nearly identical to the sun are located in this zone of the sky. The two prominent clusters are actually small galaxies known as the Large and Small Magellanic Clouds. They are about 200,000 light-years distant whereas

Zeta Reticuli is only 37 light-years away. Achernar, the brilliant star to the upper right, is a first magnitude star of great intrinsic brilliance, 118 light-years from us. None of the stars in this photo are visible from the United States (except Achernar which can be seen low on the southern horizon on December evenings from southern Florida and Texas) due to their positions near the south celestial pole.

gruence would occur in the volume of space we are discussing.

"In most fields of investigation where similar statistical methods are used, that degree of congruence is rather persuasive," concludes Saunders.

Saunders, who has developed a monumental computerized catalog of more than 60,000 UFO sightings, tells us that the Hill case is not unique in its general characteristics — there are other known cases of alleged communication with extra-terrestrials. But in no other case on record have maps ever been mentioned.

Mark Steggert of the Space Research Coordination Center at the University of Pittsburgh developed a computer program that he calls PAR (for Perspective Alteration Routine) that can duplicate the appearance of star fields from various viewpoints in space.

"I was intrigued by the proposal put forth by Marjorie Fish that she had interpreted a real star pattern for the alleged map of Betty Hill. I was incredulous that models could be used to

do an astronomic problem," Steggert says. "To my surprise I found that the pattern that I derived from my program had a close correspondence to the data from Marjorie Fish."

After several runthroughs, he confirmed the positions determined by Marjorie Fish. "I was able to locate *potential* areas of error, but no real errors," Steggert concludes.

Steggert zeroed in on possibly the only real bone of contention that anyone has had with Marjorie Fish's interpretation: The data on some of the stars may not be accurate enough for us to make definitive conclusions. For example, he says the data from the **Smithsonian Astrophysical Observatory Catalog**, the **Royal Astronomical Society Observatory Catalog**, and the **Yale Catalog of Bright Stars** "have differences of up to two magnitudes and differences in distance amounting to 40 percent for the star Gliese 59". Other stars have less variations in the data from one catalog to another, but Steggert's point is valid. The data on some of the stars in the map

is just not good enough to make a definitive statement. (The fact that measurements of most of the stars in question can only be made at the relatively poorly equipped southern hemisphere observatories accounts for the less reliable data.)

Using information on the same 15 stars from the Royal Observatory catalog (Annals #5),

Stegert reports that the pattern does come out differently because of the different data, and Gliese 59 shows the largest variation. The Gliese catalog uses photometric, trigonometric and spectroscopic parallaxes and derives a mean from all three after giving various mathematical weights to each value. "The substantial variation in

THE 46 NEAREST STARS SIMILAR TO THE SUN

Name	Distance (light-years)	Visual Magnitude	Luminosity (sun=1)	Spectrum
Tau Ceti	11.8	3.5	0.4	G8
82 Eridani	20.2	4.3	0.7	G5
Zeta Tucanae	23.3	4.2	0.9	G2
107 Piscium	24.3	5.2	0.4	K1
Beta Comae Berenices	27.2	4.3	1.2	G0
61 Virginis	27.4	4.7	0.8	G6
Alpha Mensae	28.3	5.1	0.6	G5
Gliese 75	28.6	5.6	0.4	K0
Beta Canum Venaticorum	29.9	4.3	1.4	G0
Chi Orionis	32	4.4	1.5	G0
54 Piscium	34	5.9	0.4	K0
Zeta 1 Reticuli	37	5.5	0.7	G2
Zeta 2 Reticuli	37	5.2	0.9	G2
Gliese 86	37	6.1	0.4	K0
Mu Arae	37	5.1	0.9	G5
Gliese 67	38	5.0	1.2	G2
Gliese 668.1	40	6.3	0.4	G9
Gliese 302	41	6.0	0.6	G8
Gliese 309	41	6.4	0.4	K0
Kappa Fornacis	42	5.2	1.3	G1
58 Eridani	42	5.5	0.9	G1
Zeta Doradus	44	4.7	2.0	F8
55 Cancri	44	6.0	0.7	G8
47 Ursa Majoris	44	5.1	1.5	G0
Gliese 364	45	4.9	1.8	G0
Gliese 599A	45	6.0	0.6	G6
Nu Phoenicis	45	5.0	1.8	F8
Gliese 95	45	6.3	0.5	G5
Gliese 796	47	5.6	0.5	G8
20 Leo Minoris	47	5.4	1.2	G4
39 Tauri	47	5.9	0.8	G1
Gliese 290	47	6.6	0.4	G8
Gliese 59.2	48	5.7	1.0	G2
Psi Aurigae	49	5.2	1.5	G0
Gliese 722	49	5.9	0.9	G4
Gliese 788	49	5.9	0.8	G5
Nu 2 Lupi	50	5.6	1.1	G2
14 Herculis	50	6.6	0.5	K1
Pi Ursa Majoris	51	5.6	1.2	G0
Phi 2 Ceti	51	5.2	1.8	F8
Gliese 641	52	6.6	0.5	G8
Gliese 97.2	52	6.9	0.4	K0
Gliese 541.1	53	6.5	0.6	G8
109 Piscium	53	6.3	0.8	G4
Gliese 651	53	6.8	0.4	G8
Gliese 59	53	6.7	0.4	G8

This table lists all known stars within a radius of 54 light-years that are single or part of a wide multiple star system. They have no known irregularities or variabilities and are between 0.4 and 2.0 times the luminosity of the sun. Thus, a planet basically identical to Earth could be orbiting around any one of them. (Data from the *Catalog of Nearby Stars*, 1969 edition, by Wilhelm Gliese.)

catalog material is something that must be overcome," says Steggert. "This must be the next step in attempting to evaluate the map."

This point of view is shared by Jeffrey L. Kretsch, an undergraduate student who is working under the advisement of J. Allen Hynek at Northwestern University in Evanston, Ill. Like Steggert, he too checked Marjorie Fish's pattern and found no error in the work. But Kretsch reports that when he reconstructed the pattern using trigonometric distance measurements instead of the composite measures in the Gliese catalog, he found enough variations to move Gliese 95 above the line between Gliese 86 and Tau 1 Eridani.

"The data for some of the stars seems to be very reliable, but a few of the pattern stars are not well observed and data on them is somewhat conflicting," says Kretsch. The fact that the pattern is less of a "good fit" using data from other sources leads Kretsch and others to wonder what new observations would do. Would they give a closer fit? Or would the pattern become distorted? Marjorie Fish was aware of the catalog variations, but has assumed the Gliese catalog is the most reliable source material to utilize.

Is the Gliese catalog the best available data source? According to several astronomers who specialize in stellar positions, it probably is. Peter Van de Kamp says, "It's first rate. There is none better." He says the catalog was compiled with extensive research and care over many years.

A lot of the published trigonometric parallaxes on stars beyond 30 light-years are not as accurate as they could be, according to Kyle Cudworth of Yerkes Observatory. "Gliese added other criteria to compensate and lessen the possible errors," he says.

The scientific director of the U. S. Naval Observatory, K. A. Strand, is among the world's foremost authorities on stellar distances for nearby stars. He believes the Gliese catalog "is the most complete and comprehensive source available".

Frank B. Salisbury of the University of Utah has also examined the Hill and Fish maps. "The pattern of stars discovered by Marjorie Fish fits the map drawn by Betty Hill remarkably well. It's a striking coincidence and forces one to take the Hill story more seriously," he says. Salisbury is one of the few scientists who has spent some time on the UFO problem and has written a book and several articles on the subject. A professor of plant physiology, his biology expertise has been turned to astronomy on several occasions while studying the possibility of biological organisms existing on Mars.

Salisbury insists that while psychological factors do play an important role in UFO phen-

omena, the Hill story *does* represent one of the most credible reports of incredible events. The fact that the story and the map came to light under hypnosis is good evidence that it actually took place. "But it is not unequivocal evidence," he cautions.

Elaborating on this aspect of the incident, Mark Steggert offers this: "I am inclined to question the ability of Betty, under posthypnotic suggestion, to duplicate the pattern two years after she saw it. She noted no grid lines on the pattern for reference. Someone should (or perhaps has already) conduct a test to see how well a similar pattern could be recalled after a substantial period of time. The stress she was under at the time is another unknown factor."

"The derivation of the base data by hypnotic techniques is perhaps not as 'far out' as it may seem," says Stanton Friedman. "Several police departments around the country use hypnosis on rape victims in order to get descriptions of the assailants — descriptions that would otherwise remain repressed. The trauma of such circumstances must be comparable in some ways to the Hill incident."

Is it at all possible we are faced with a hoax?

"Highly unlikely," says Salisbury — and the other investigators agree. One significant fact against a charade is that the data from the Gliese catalog was not published until 1969, five years after the star map was drawn by Betty Hill. Prior to 1969, the data could only have been obtained from the observatories conducting research on the specific stars in question. It is not uncommon for astronomers not to divulge their research data — even to their colleagues — before it appears in print. In general, the entire sequence of events just does not smell of falsification. Coincidence, possibly; hoax, improbable.

Where does all this leave us? Are there creatures inhabiting a planet of Zeta 2 Reticuli? Did they visit Earth in 1961? The map indicates that the sun has been "visited occasionally". What does *that* mean? Will further study and measurement of the stars in the map change their relative positions and thus distort the configuration beyond the limits of coincidence?

The fact that the entire incident hinges on a map drawn under less than normal circumstances certainly keeps us from drawing a firm conclusion. Exobiologists are united in their opinion that the chance of us having neighbors so similar to us, apparently located so close, is vanishingly small. But then, we don't even know *for certain* if there is *anybody at all* out there — anywhere — despite the Hill map and pronouncements of the most respected scientists.

The only answer is to continue the search. Someday, perhaps soon, we will know. 

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What's in Martian Craters?

by
Joseph Veverka

For 350 years we have been aware of the craters that seem to cover virtually every part of the surface of our nearest neighbor in space — the moon. But only with the Mariner 4 flight 10 years ago did we finally get a look at the craters of our most intriguing neighbor, Mars. Since then a series of more sophisticated space probes has shown us that craters are one of the most common features on the surface of the red planet.

The craters of Mars differ in many ways from those on the moon, but perhaps the most important difference is that many Martian craters have, on their floors, prominent bright and dark markings which (for the lack of a better name) have become known as "splotches". What are these splotches, and why are they so common on Mars? As we will see, part of the answer seems connected to Mars' tenuous but rapidly circulating atmosphere; another, with the fact that Mars, like Earth, is a geologically active planet — it has volcanos, earthquakes (Marsquakes?), and signs of crustal shifting.

When Mariner 9 went into orbit around Mars in late 1971, it found the planet completely blanketed by dust, whipped to the highest levels of

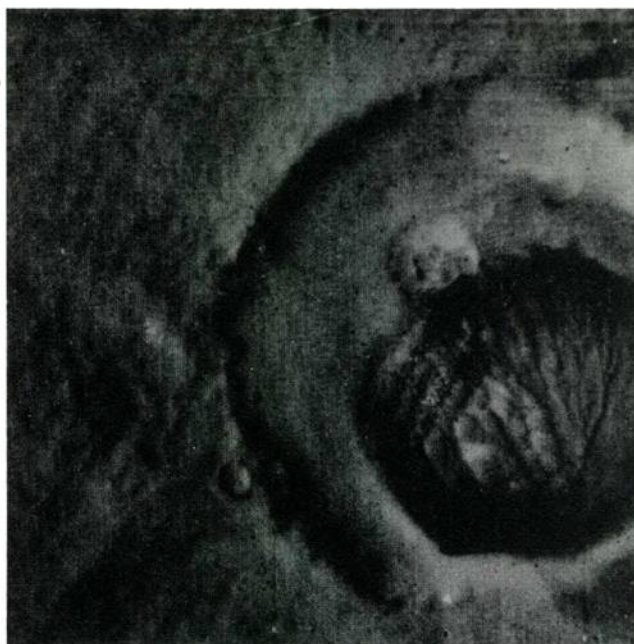
the Martian atmosphere by savage 250 m.p.h. winds. Mariner 9 proved that strong winds capable of carrying sand and dust are, in fact, common on Mars. Most of this windblown material is bright but some of it is also very dark. At this point we aren't sure whether the difference is one of grain size (fine particles versus coarse particles) or one of composition as well (bright minerals versus dark minerals).

Some of this windblown sand and dust must get trapped preferentially in crater bottoms — since craters are, after all, depressions in the surface. Thus some of the dark splotches could be accumulations of dark windblown material. In fact, Mariner 9 photography proves that this is precisely what some crater splotches are. One example is the dune field of dark sand on the floor of a 90 mile wide crater in Hellespontus (shown in the photo on page 24). The dunes here are higher than the Great Pyramids! Since they cover an area roughly 20 miles wide and 40 miles long, the amount of dark windblown sand accumulated within this crater is colossal — some 100 billion tons!

But there is another way in which Martian winds can produce dark crater splotches. As the winds blow over a crater the wind speed is modified — in some places the velocity is increased and the wind finds it easier to pick up and carry dust from the surface. Now suppose the bedrock at the bottom of a crater is relatively dark and has been covered over by a thin layer of bright dust following one of the many Martian dust storms. As

A weird bright "splotch", covering about 150 square miles inside a huge crater on Mars, is totally unlike anything seen inside lunar craters. The nature of this and other newly discovered features of Mars are discussed in this article. The contrast of this Mariner 9 photograph has been enhanced and color was added to duplicate the hues of Mars.

NASA Photograph



A giant dune field (left) and possible lava flow (right) indicate that dark crater interiors on Mars can be due to different processes. All photos in this article have received considerable contrast enhancement to bring out subtle details.

NASA Photographs

winds blow over the crater, scouring will occur in the places where the wind velocity is increased; the bright dust veneer is removed, and the dark bedrock is exposed. The result is a dark crater splotch.

Erosional splotches, produced by blowing away a small veneer of bright dust from the underlying material, can develop and change rather quickly since only small amounts of dust need be transported to produce a visible change. It is not surprising that changes in such splotches were observed during the Mariner 9 mission. On the other hand, dunelike splotches, produced by deposition, cannot change very quickly since any visible change would require moving large quantities of material.

About 15 percent of the crater splotches photographed by Mariner 9 at high resolution show definite morphological structure which indicates that they may be accumulations of dark material, rather than mere superficial wind erosion scars. In many cases a definite dune pattern is evident in such structured splotches; in others, the pattern is more suggestive of a solidified flow.

In the photos above we see two nearby craters of similar size. The dark splotch in the lower crater is almost certainly a dune field, but the splotch in the other crater has a structure with a very definite concentric pattern — more consistent with a flow spreading from a central fissure than with a dune field. Can this splotch be a solidified flow of dark lava? Often, as in this case, we cannot be sure. What looks like a solidified lava flow may

perhaps be simply a very unusual accumulation of dark windblown dust.

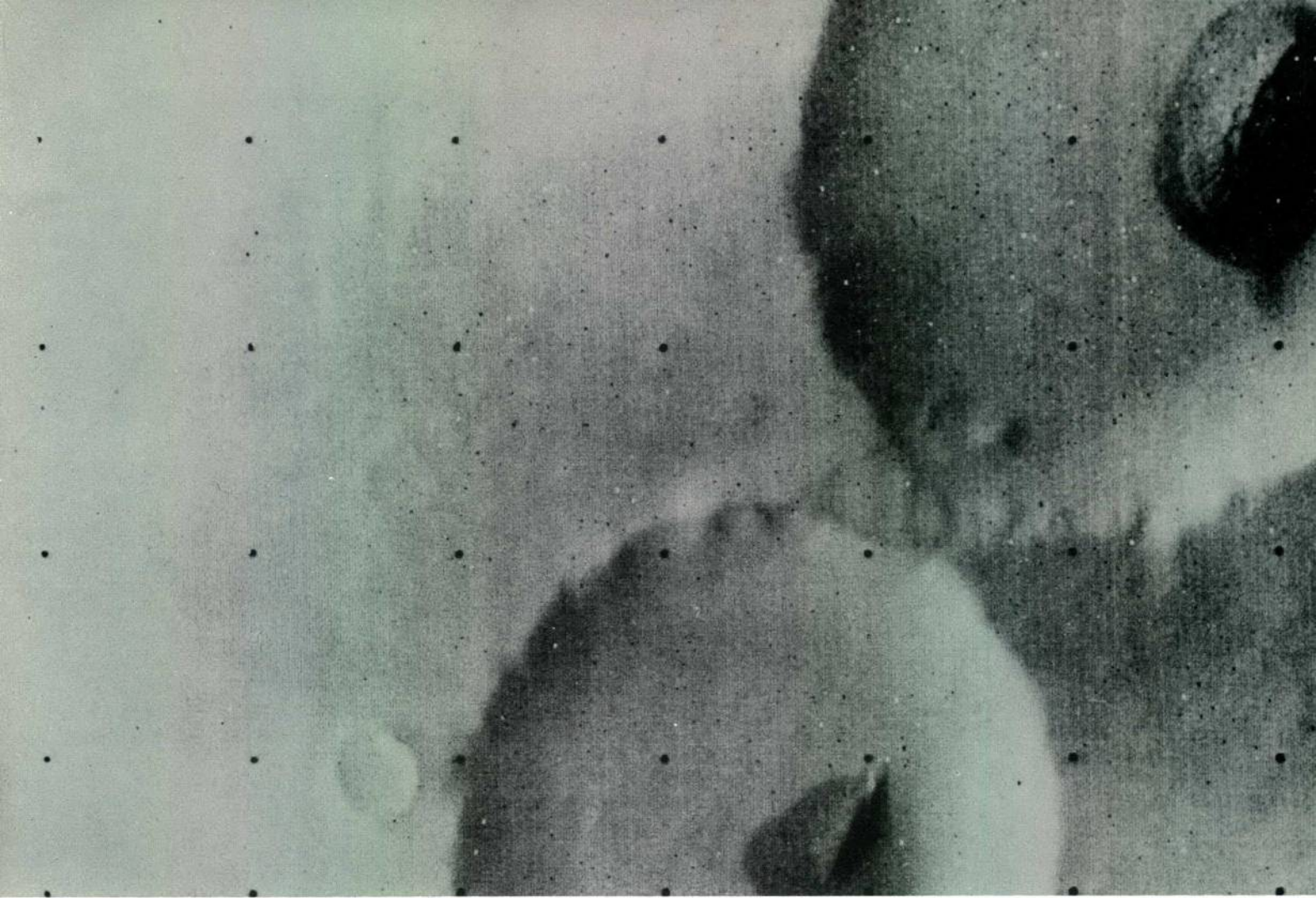
In the photo on page 23, however, we have two dark splotches which are almost certainly intrusive. They are hills of dark material with fissures running through them, and occur off-center in their craters (unlike central peaks). Notice also that the fissures appear to define a straight line. These features must have formed later than the craters which they occupy. Their appearance as well as the fact that they are cut by fissures which define a straight line suggest that they consist of dark rock erupted as lava along a fault which runs through the two craters. The erupted material may be a dark basalt.

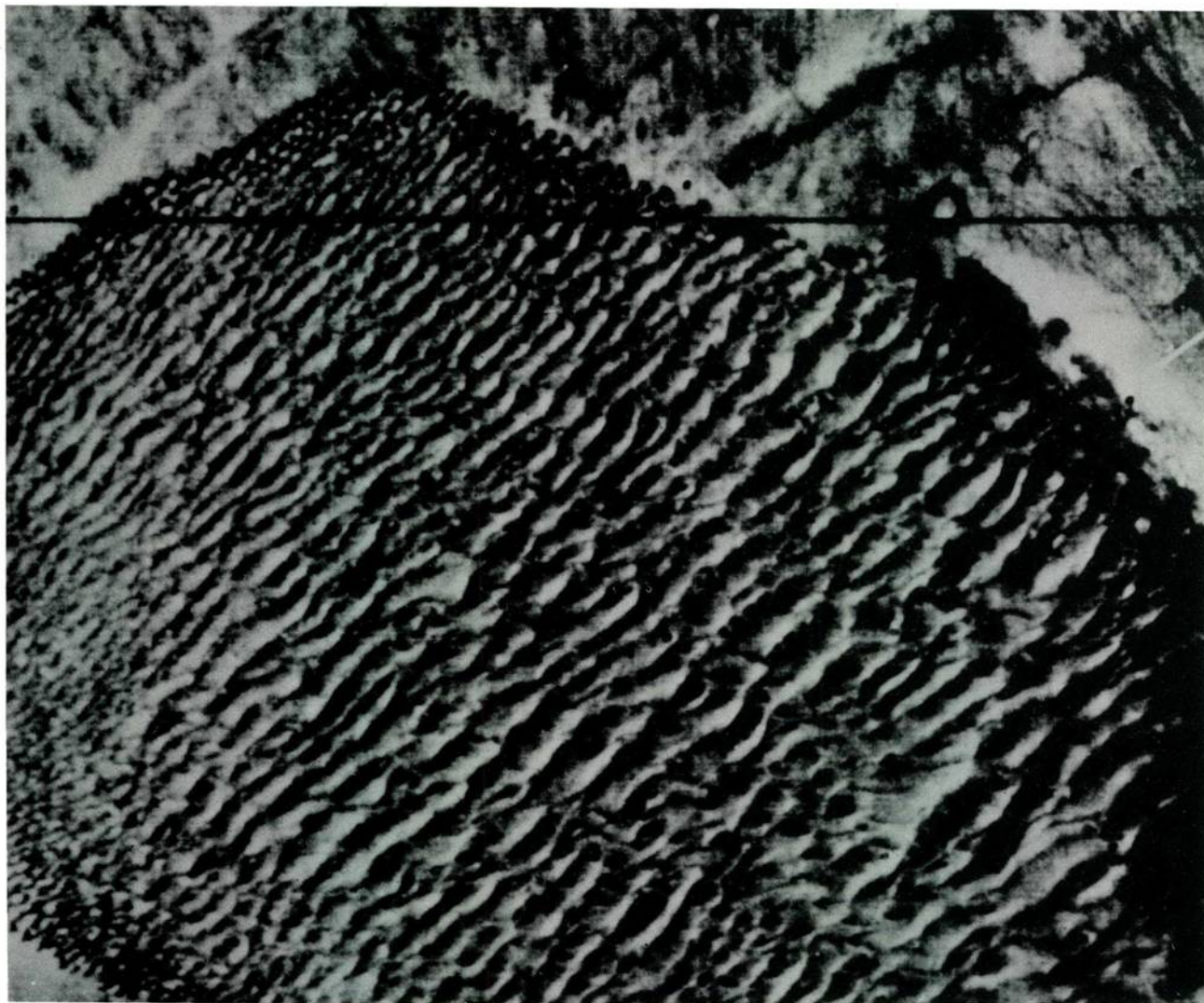
In at least one case, a bright splotch occurs within a crater. This unusual "white" rock (shown on page 20) lies inside a 60 mile wide crater in Sabeus Sinus. Although deeply weathered and eroded, the splotch definitely formed after the crater — since it now sits on the crater floor. This white rock may have been formed by the intrusion of rock onto the crater floor. But in this case, the rock was probably acidic and therefore much brighter than the dark, basaltic rock material which appears to be so common on Mars.

The presence of flows or intrusions on a crater floor doesn't necessarily mean that the crater is

A region of Mars littered with dark splotches (lower) was photographed by Mariner 9 in 1972. Recent interpretation of some of these curious features shows that, while many are erosion scars, some are giant sand dune fields and others may even be lava flows. This is a 400 mile wide low resolution photo; the other photographs in this article were taken with Mariner 9's high resolution camera. Two dark splotches (upper) scar the interiors of adjacent craters in this 1972 Mariner 9 photo. The author believes these dark areas are volcanic magma that has pushed up through the weak crater floors. The lower crater is 35 miles in diameter.

NASA Photographs





NASA Photograph

A giant sand dune field on Mars covers an 800 square mile area inside a 90 mile wide crater. The largest dunes are

1,000 feet high. To an explorer on Mars, this desert would bear a remarkable resemblance to its earthly counterparts.

volcanic in origin. Not only can molten rock intrude onto the floor of a nonvolcanic impact crater, but such an intrusion may occur long after the original crater is formed.

Consider the following possible, but speculative, scheme: A small asteroid plunges into the surface rock producing a crater. In the process not only is a large amount of material excavated, but the rock below and around the crater is severely fractured and pulverized. If, at a later stage, subsurface magma is produced in the area, the easiest place for it to flood onto the surface will be at the crater bottom — both because the crater floor is closer to the magma source than the surroundings, and because the fractured rock below the crater provides ready made fissures and pathways for the magma to reach the surface.

So, as you can see, there is no simple explanation for the weird splotches on the floors of Martian craters. We also have to consider that much of our speculation may turn out to be incorrect. But we have at least begun to try to understand a

feature of Mars that we didn't even know existed only a few years ago.

It is unlikely that we have seen all the varieties of splotches that occur in Martian craters. After all, even though Mariner 9 photographed the entire surface of Mars down to a resolution of about one mile, high resolution photography is required to show the splotches in detail — and only one percent of the Martian surface was surveyed in this way. There may still be a lot more in Martian craters than we have yet seen or imagined!

For additional information on the surface of Mars, see these issues of *ASTRONOMY*: "The Surface of Mars", September 1973; "The Canals of Mars", April 1974; "The Lost Pictures of Mars", May 1974. 🗿

Dr. Joseph Veverka is assistant professor of astronomy at Cornell University's Laboratory for Planetary Studies in Ithaca, N.Y. He has been deeply involved in the interpretation of the Mars photos returned from Mariner 9, and is author or co-author of numerous published research articles.

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Milky Way in Sagittarius



The detailed cover photograph of ASTRONOMY's March 1974 issue is now a colorful 17 x 22 inch blow-up lithograph. A

host of celestial objects at our galaxy's core are recorded in full color in this breathtaking photograph by Orien A. Ernest. The gossamer, golden beauty of the Sagittarius star clouds is revealed in magnificence unsurpassed by any other color Milky Way photograph. This beautiful lithograph is also available framed (21 x 26 inches) and ready for immediate hanging as shown above.

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Mars as Seen From Deimos



The artistic imagination of Victor Costanzo is boldly displayed in this 17 x 22 inch full color lithograph of the red planet Mars as it would look from its outer satellite Deimos. Costanzo's

painstaking accuracy in this rendition is given further credence because he incorporated real constellations in the sky background. To the lower left of the planet is the Hyades star cluster in Taurus, and to the upper right is the constellation Aries. This artwork was first used as a two page spread in ASTRONOMY's May 1974 issue to illustrate "The Lost Pictures of Mars" by Carl Sagan.

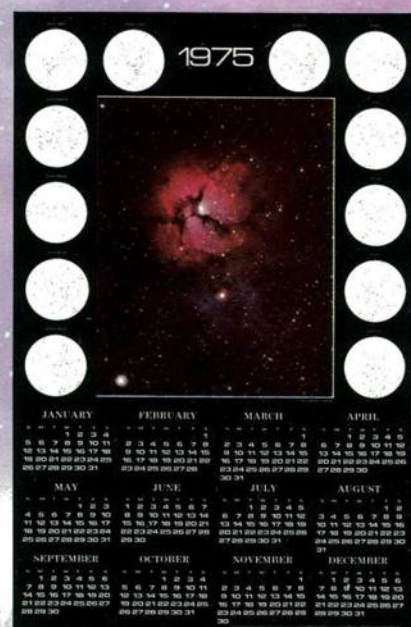
This lithograph is also available framed (21 x 26 inches) and ready for immediate hanging as shown above. Framed price:

\$22.95 each (includes shipping and handling), Unframed price: \$2.50 each (includes first class postage).

1975 Trifid Calendar

1975 is just around the corner and in keeping with ASTRONOMY's Orion Calendar of last year, we've designed an even more beautiful 22 x 34 inch offering just in time for Christmas. This beautiful poster calendar shows a blow-up view of the Trifid nebula — one of the most colorful jewels of the universe — in the constellation Sagittarius. The photograph — one of the sparkling, new, color photographs from Kitt Peak National Observatory — has never been published this large before. Gossamer shadings of red and blue draw your mind into the depths of the awesome universe. Surrounding the photograph are 12 sky maps, one for each month

of the year, making the 1975 Trifid Calendar not only beautiful but doubly useful. At the end of the year all you have to do is cut off the calendar portion and you will have a wall hanging of lasting beauty. Join the thousands who discovered the uncompromising beauty and quality of our Orion Calendar and order your 1975 Trifid Calendar today. What a timeless Christmas gift!
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SKY ALMANAC

Celestial Sights Abundant This Month

After a few months of inactivity the sky is loaded with spectacles — a sort of year-end extravaganza. Most dramatic will be the partial eclipse of the sun on the 13th; this month's Gazer's Gazette is devoted entirely to that event. The year's second best meteor shower will occur the night following the eclipse. And all month we will be treated to Saturn and Jupiter — both now in the evening sky.

Partial Solar Eclipse

Most of North America will be treated to a partial coverup of our star as the moon sweeps in front of it on Dec. 13, 1974. Observing tips, photographic hints, timetable and more are detailed in Gazer's Gazette, beginning on page 41.

Geminid Meteors

Usually the year's best meteor shower apart from the Perseids, the December Geminids will reach their peak on the morning of Dec. 14. The conditions this year are very favorable — the best in years for the Geminids — so mark the night of Dec. 13-14 down on your observing calendar. With a new moon we don't have to worry about annoying moonlight like we did with the Perseids. The predicted peak activity, according to

Canadian meteor expert Peter M. Millman, will be around 5:00 a.m. EST the morning of the 14th.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Dec. 1	1	3:51 p.m.	6:06 p.m.
6-7	1	11:18 p.m.	1:33 a.m.
7-8	2	9:51 p.m.	12:35 a.m.
8	1	5:47 p.m.	8:02 p.m.
11	3	2:59 p.m.	6:12 p.m.
15	1	7:43 p.m.	9:58 p.m.
18	3	7:02 p.m.	10:14 p.m.
22	2	9:39 p.m.	11:54 p.m.
24	1	4:08 p.m.	6:23 p.m.
25	2	4:21 p.m.	7:05 p.m.
31	1	6:04 p.m.	8:19 p.m.
Jan. 1	2	6:57 p.m.	9:41 p.m.

1 = Io

2 = Europa

3 = Ganymede

4 = Callisto

There may be as many as one meteor per minute (a rough average) within an hour of that time. Around midnight the rate may be half that figure. (See the August 1974 issue, pages 24-28, for observing tips.)

Like all meteors that come in predictable showers, the Geminids are believed to be the remains of a disintegrated comet whose orbit Earth crosses every year at this time.

Jupiter

High in the south as darkness falls, the brightest object in the night sky (other than the moon) is now noticeably dimmer than it was in early September. At that time Jupiter was a dazzling magnitude -2.5, but on Dec. 1 it is -2.0 and by New Year's it will be down to -1.8, only 50 percent of its former brightness. This change is largely due to Earth's motion away from the giant planet. Compared to a separation of 374 million miles at closest approach on Sept. 6, Jupiter will be 453 million miles distant on Dec. 1 and 495 million miles away on the 31st. The apparent equatorial diameters of Jupiter for those same three dates are: 49.5, 40.3 and 37.0 seconds of arc. As always, the giant planet's swift rotation bulges the equator producing a polar diameter seven percent smaller.

Since the area of a planet's visible surface varies with the square of the distance, Jupiter will be only 61 percent as large in your telescope on Dec. 15 as it was in early September. Thus the favorable season for Jupiter observing is now over. In addition, the big planet drifts down toward the southwest horizon well before midnight placing it in a less favorable position for



Photograph by Leo C. Henzl Jr.

Jupiter displays its multicolored cloud belts and famous Red Spot in a three second exposure on High Speed Ektachrome. A Celestron eight inch telescope was employed along with a DOAA planetary camera.



Photograph by Patrick Michaud

The setting sun, reddened and dulled by our atmosphere, was photographed without filtration through an eight inch telescope on Sept. 15, 1974. The giant sunspot group near center was visible to the unaided eye — which means that it was several times the size of Earth. The sunspot and the area around it erupted with a violent flare that ultimately produced the aurora pictured on page 32. Unfiltered solar photography such as this is possible only under the conditions outlined in this month's Gazer's Gazette. The Kodachrome 64 film was exposed for 1/60 second.

clear examination of the shifting clouds that cover Jupiter's surface.

The discouraging words apply only to detailed observations of Jupiter's cloud features. We are simply saying it is harder to see what was clearly visible earlier in the year. But for the other attraction of Jupiter — the four big moons — the increased distance has much less impact. Any small telescope still shows all four, dancing from side to side in their endless twirling around their master.

A rare combination of satellite events combine on the evening of the 7th. Take a look at the satellite position chart on page 29. On the 7th, only one moon — Callisto — is visible. Where are the others? From 7:25 p.m. to 9:59 p.m. EST that evening, three moons will be either behind or in front of Jupiter, or in the planet's shadow. Here is the itinerary: Io moves behind Jupiter at 7:11 and eventually emerges from Jupiter's shadow at 10:46; Europa will be in front of the planet and appear to blend in with its cloud belts from 7:13 to 9:59; finally Ganymede makes the same trip behind Jupiter that Io does, disappearing at 7:25 and re-emerging at 10:51. Io will emerge from Jupiter's shadow, but Ganymede won't — it will pop out from behind Jupiter's disk instead. Ganymede dips into the shadow much later, from 10:56 p.m. to 2:12 a.m. The only continuously visible aspect of the series of events will be Europa's shadow on Jupiter (see shadow transit table).

All in all, the nearly "satelliteless" Jupiter on Dec. 7 will provide interesting viewing, even in a small telescope. Make a log using the times given here and watch for each event.

On several occasions this fall the shadow of Ganymede happened to fall right on the Great Red Spot. One attempt to capture the event on film was remarkably successful as shown on this page. The Red Spot itself continues to be prominent. We have reports from owners of 2.4 inch refractors describing their surprise at the spot's visibility. Once you have seen the spot you can use a rotation rate of 9 hours, 55 minutes to predict when it will next be visible.

Saturn

By three hours after sunset, Saturn is well up in the eastern sky and shines brighter than any



Photograph by James K. Rouse

Both Jupiter's largest moon, Ganymede, and its shadow are seen in this eight inch telescope photo taken Sept. 30, 1974. The shadow, partly obscuring the oval Great Red Spot, is much more prominent than Ganymede itself which is seen on the opposite side of Jupiter's white south tropical zone. Ganymede actually has a gray appearance compared with the inky blackness of the shadow. The detail captured in this five second exposure of a 7mm eyepiece projection should be visible through a four inch telescope. The Kodak SO-410 film was developed in H & W Control Developer.

SATELLITES OF JUPITER DECEMBER					
1	31024	• • ● • •	16	01234	• • • • •
2	01234	• • • • •	17	10234	• • • • •
3	10324	• • • • •	18	23014	• • • • •
4	2301	• • • • •	19	32104	• • • • •
5	34210	• • • • •	20	30142	• • • • •
6	43012	• • • • •	21	34102	• • • • •
7	40	• • • • •	22	4203	• • • • •
8	42103	• • • • •	23	403	• • • • •
9	40123	• • • • •	24	41023	• • • • •
10	41032	• • • • •	25	42301	• • • • •
11	42301	• • • • •	26	43210	• • • • •
12	32140	• • • • •	27	43012	• • • • •
13	30142	• • • • •	28	43102	• • • • •
14	1024	• • • • •	29	24013	• • • • •
15	21034	• • • • •	30	2043	• • • • •
			31	10234	• • • • •

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 8 p.m. (EST) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto, and 0 = Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

of the stars of the constellation Gemini. The ringed planet is now visiting that zodiac group and makes a distinctive triangle with Castor and Pollux. Saturn is magnitude 0.0 on the 1st and brightens to -0.2 by month's end. The increase in brightness takes Saturn into the minus magnitudes and elevates it to third brightest star or planet in the evening sky (only Jupiter and Sirius are brighter).

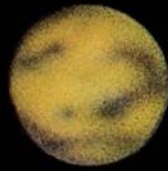
The increase in brightness of Saturn doesn't mean the planet is changing in any way; we are simply moving toward it and will continue to do so until early next year. The distance between Earth and Saturn on the 1st is 765 million miles; this decreases to 748 million miles by the 31st. Saturn's rings, now well tipped for our inspection, are 45.5 seconds of arc in apparent width on the 1st and increase to 46.6 seconds by New Year's Eve. This means that in your telescope, Saturn's rings now appear wider than the equatorial diameter of Jupiter. The disk of the distant planet itself will be about 19 seconds wide all month.

Saturn's big moon, Titan, can be seen as an eighth magnitude object orbiting the planet in about 16 days. A 2.4 inch refractor should be enough to follow it all the way around. Titan will be at its maximum distance — about five ring diameters — west of Saturn on the 5th and 21st. (West is to the left of Saturn when the planet is oriented like the illustration on page 30.)



© Ceres

Dec.	1	15
R.A.	22h45m	22h57m
Dec.	+9°41'	-17°44'
Mag.	+8.0	+8.2



Ⓐ Mercury

Dec.	1
R.A.	15h45m
Dec.	-14°11'
Mag.	-0.6

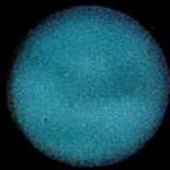
Ⓑ Mercury

Dec.	15
R.A.	17h22m
Dec.	-24°15'
Mag.	-0.7



Ⓜ Mars

Dec.	1	15
R.A.	15h25m	16h06m
Dec.	-18°36'	-20°54'
Mag.	+1.8	+1.8



Ⓝ Neptune

Dec.	15
R.A.	16h33m
Dec.	-20°25'
Mag.	+7.7



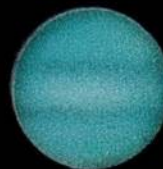
SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.



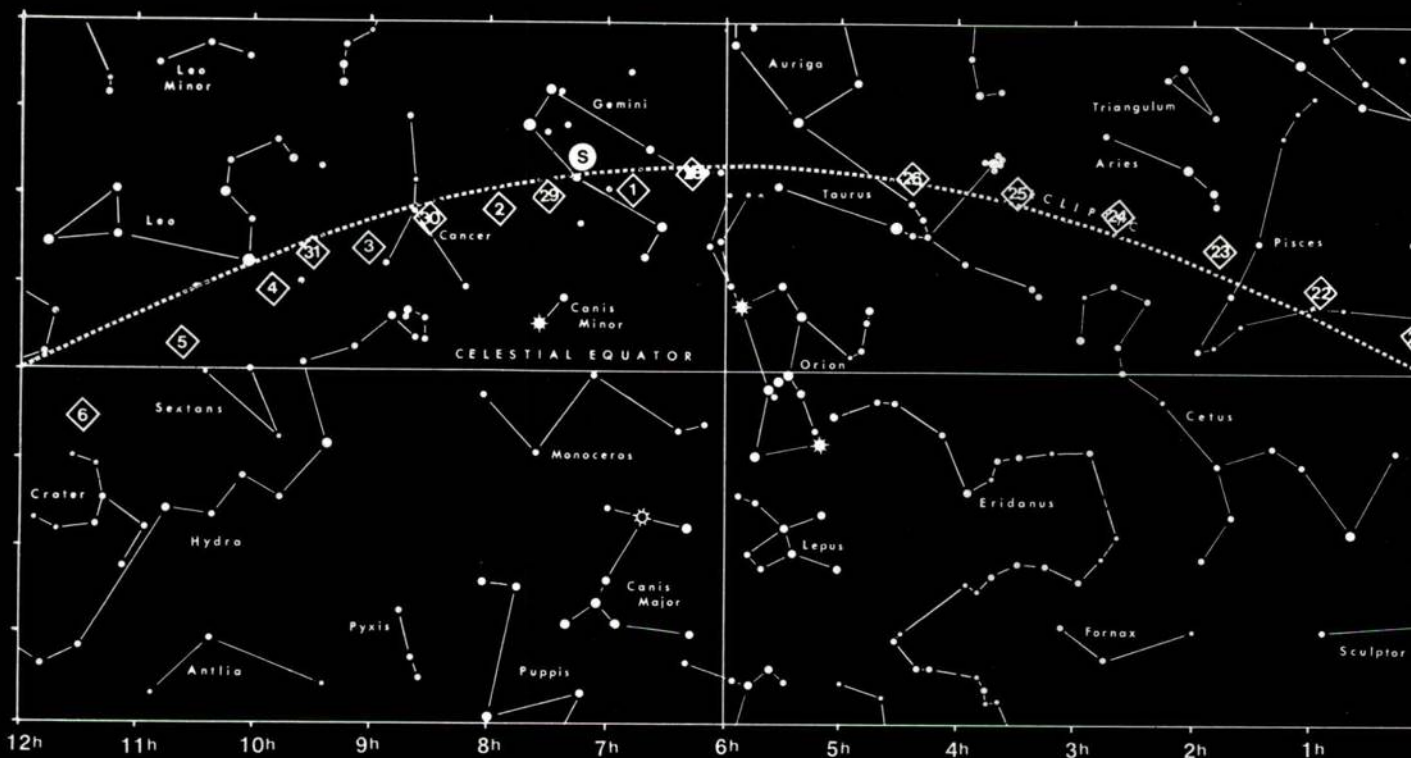
Ⓢ Saturn

Dec.	1	15
R.A.	7h17m	7h14m
Dec.	+21°47'	+21°55'
Mag.	0.0	-0.1



Ⓤ Uranus

Dec.	15
R.A.	13h57m
Dec.	-11°25'
Mag.	+5.8



Map by Raymond G. Coutchie

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a



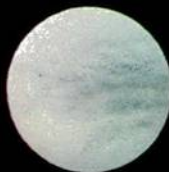
Ⓥ Vesta

Dec.	1	15
R.A.	17h26m	17h54m
Dec.	-24°54'	-22°30'
Mag.	+7.8	+7.8



♃ Jupiter

Dec.	1	15
R.A.	22h40m	22h51m
Dec.	-9°13'	-8°35'
Mag.	-2.0	-1.9



♀ Venus

Dec.	1	
R.A.	16h57m	
Dec.	-22°52'	
Mag.	-3.4	

♁ Venus

Dec.	15
R.A.	18h14m
Dec.	-24°08'
Mag.	-3.4



♇ Pluto

Dec.	15
R.A.	12h58m
Dec.	+11°48'
Mag.	+14.3



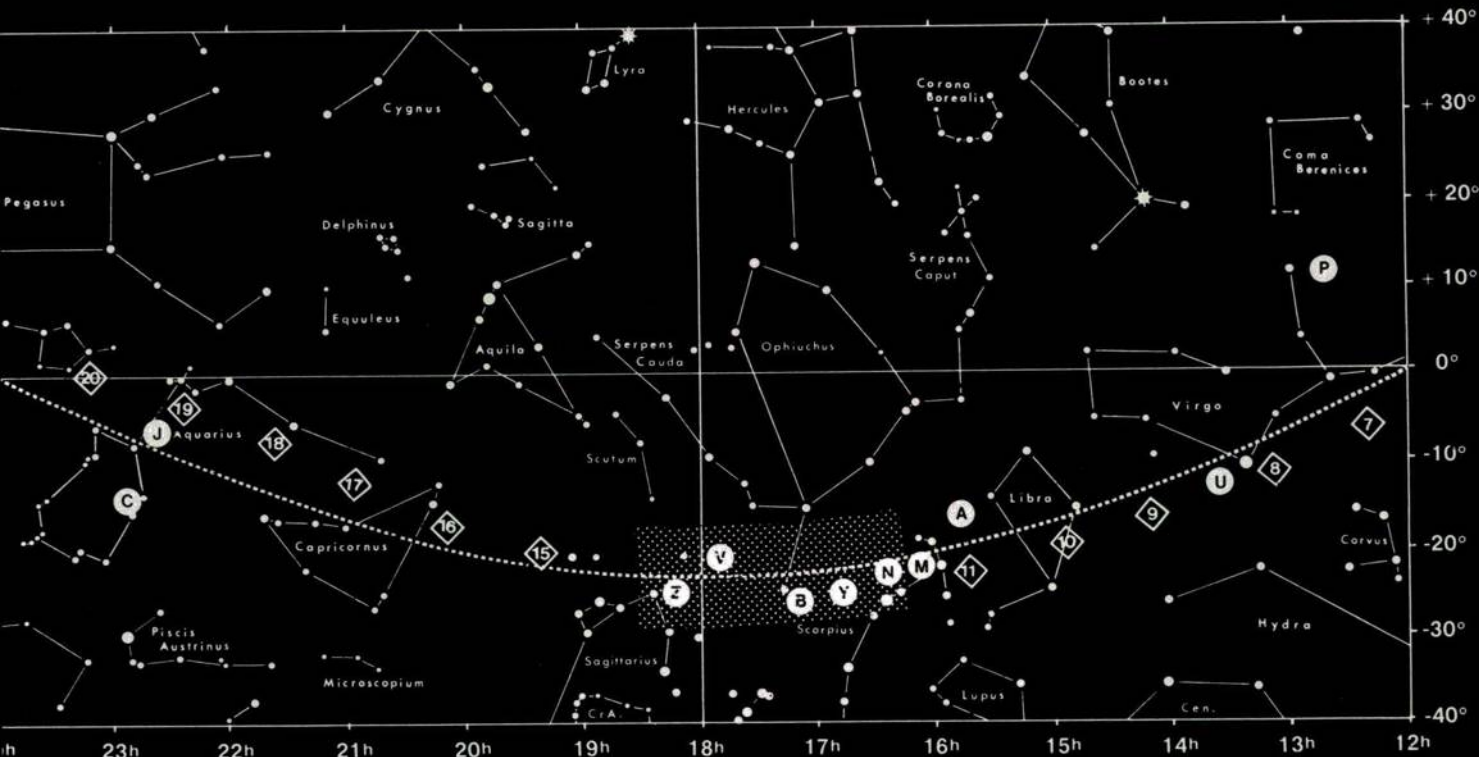
First Quarter
Dec. 21



Full Moon
Dec. 28



Last Quarter
Dec. 6

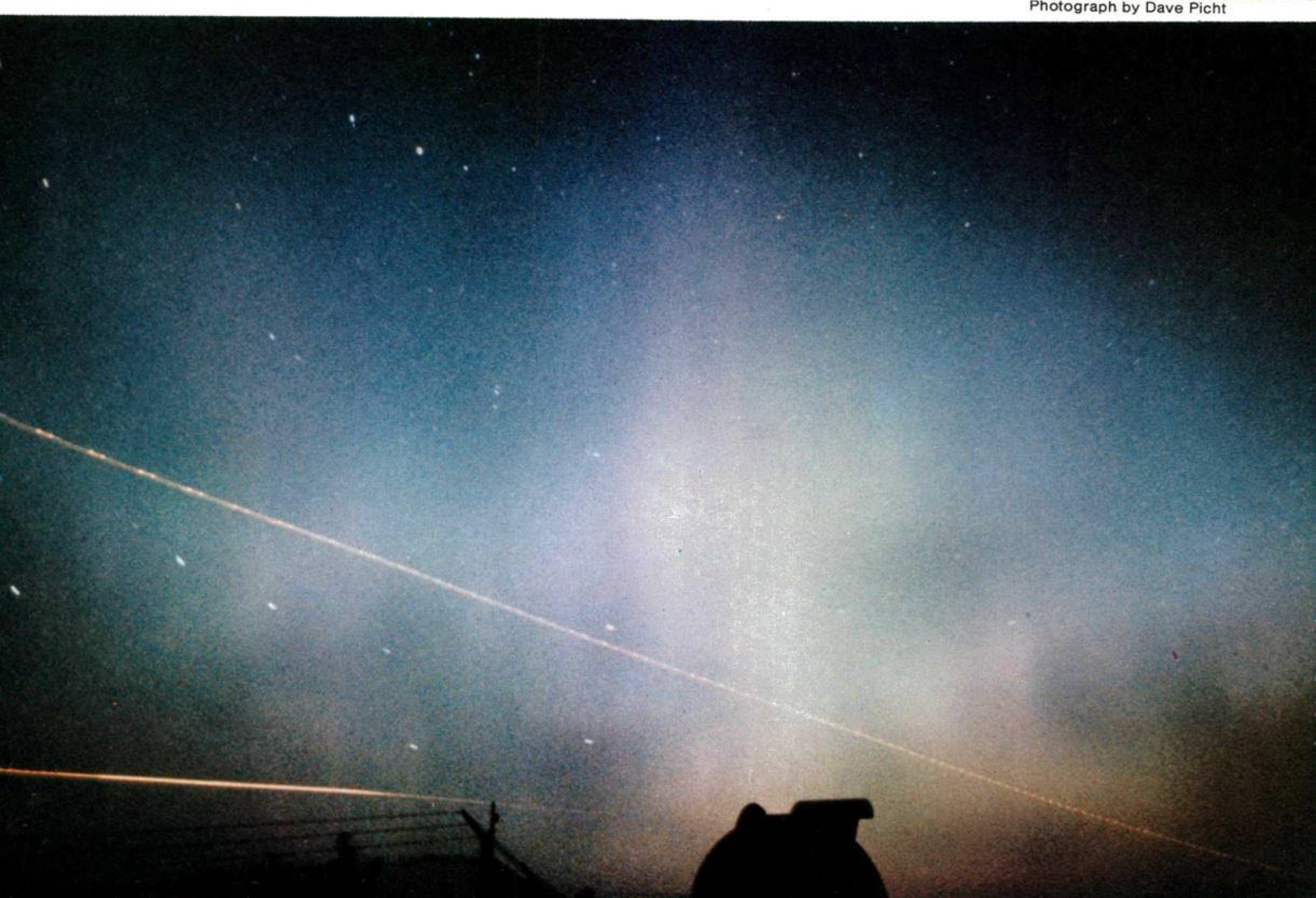


Artwork by Victor Costanzo

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.



Photograph by Dave Picht





Photograph by Steven Wheatcraft

A 15 mile wide flying mountain, 57 million miles from Earth, hurtled across 20,000 miles of space and left a telltale streak on the film (center). The interloper is the asteroid Eros on its way to a rendezvous with Earth in Jan. 1975 (see *ASTRONOMY*, October 1974). This photo, taken Oct.

7, 1974, shows the 12th magnitude Eros as a streak because the Celestron eight inch telescope was trained on the stars causing the moving asteroid to make a trail 45 seconds of arc in length. The exposure was 25 minutes on Kodak 103aF film.

Mercury, Venus, Mars, Uranus, Neptune, Pluto

If Saturn and Jupiter were not in such good sky locations, planet observers would be in bad shape. The six planets listed above are all in poor or impossible positions for observation.

Longest Nights

The last two weeks of December provide the

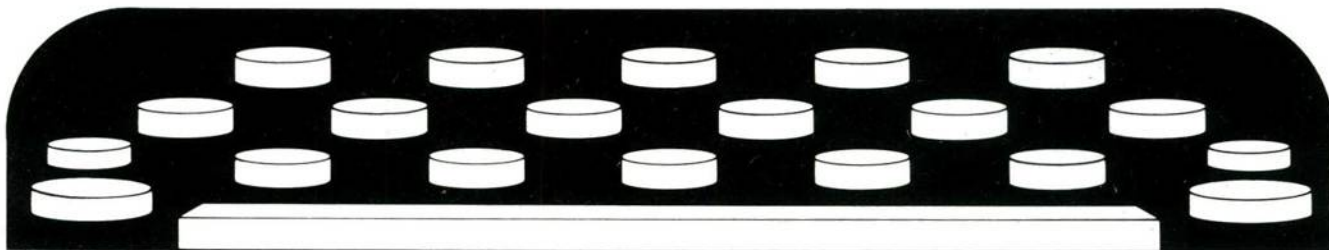
The violence associated with the sunspot in the solar photo on page 28 was responsible for an auroral display on the night of Sept. 15-16, 1974. Energetic particles from the sun interact with the upper atmosphere as they spiral in toward Earth's magnetic poles. In the process they release energy in the form of light. In the upper photo, taken near Cedar Falls, Iowa, a one minute exposure on High Speed Ektachrome captured a rippling auroral curtain in front of the stars of the Big Dipper. The lower photo, a two minute exposure on GAF 500, was taken in the same general direction from Avon, Conn. (The bright streaks on the photo are passing aircraft.) Photographer Atwood reports that this aurora was the exception to the poor displays he has witnessed from his locale in recent years. However, other reports of this aurora indicate it was not as intense as the July 5, 1974 display in most parts of the country.

Photograph by Philip F. Atwood

longest nights of the year for northern hemisphere observers. Unfortunately this is offset by bad weather over many parts of the United States.

Looking forward to 1975 there are some predictable events of importance. There will be two total eclipses of the moon. One, on May 24, will be seen in the evening hours from most of this country. The other will be observable from parts of North America. Neither of next year's two partial eclipses of the sun will be visible from North America. We will have a moderately favorable approach to Mars in Dec. 1975, and an exciting "visit" with the asteroid Eros in January (described fully in the October 1974 issue).

Then there are the unexpected events. We had two comets in 1974 — more than our share even though Kohoutek was a major disappointment. But we are overdue for a naked eye nova, so let's hope for action on a distant star to give us some celestial surprises. Anyway, we'll be here each month to keep you informed. 🐸



IN FOCUS

Sir / I have been an amateur astronomer for 15 years. In all that time I had never witnessed a phenomenon I considered completely inexplicable — until I observed an object in the constellation Cygnus on the morning of July 17, 1974.

Conditions were particularly favorable at my site at Primrose, Pa., and I had gone out to observe the Milky Way. I was tracing the outline of the Milky Way in the region of Cygnus when I noticed a first magnitude star near Deneb. I knew there was no bright star that close to Deneb, so I studied it more closely and noticed it was moving. The object moved from the vicinity of Deneb to the vicinity of Alderamin (Alpha Cephei) in approximately five minutes. It appeared to move in an erratic line.

My first hypothesis about the nature of the object was that it was a bright artificial satellite. I attributed the apparent erratic motion to the autokinetic illusion so common while observing a single point. I was interested in the brightness of the object. Not only was the "satellite" bright but it was uniformly bright. Many of the artificial satellites I had observed in the past changed brightness due to rotation while in orbit.

When the object reached the area of Alderamin it abruptly stopped and reversed its motion. It obviously was not an artificial satellite. I went in to get my telescope for a closer look at the object, but by the time I returned it had disappeared.

I would be interested in any explanation

you or your subscribers may have for such an object. It was much too slow to be a meteor, and was exactly like a first magnitude star except for its motion. It certainly would be recorded on any photographic plates made of the region between Cygnus and Cepheus on the morning of the 17th between 12:25 and 12:30 a.m. EDT.

I would appreciate any assistance you could give me in discovering the identity of this object. I find it very unpleasant to number myself among the many "UFO observers".

ROBERT JOHN PURDY
Pottsville, Pa.

Sir / Last night (Sept. 30) my students and I all clearly saw a satellite "shadow" on Jupiter, but I can't tell what

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moon could have cast the shadow!

To be specific, we had a beautiful view of the transit of Ganymede's shadow beginning at 8:35 p.m. MST. In our Dynamax 8, the shadow was clear and bold and contrasted nicely with the Red Spot just to the west of it. But before that shadow transit had started, we'd been studying another shadow that was already on the west side of the disc of Jupiter. It was smaller and not as dark, but definitely round. It sat amid one of the light colored zones (the same one in which the Red Spot circulates), and it moved off the planet more rapidly, I think, than the rotation speed of Jupiter itself. My first thought was Europa, since that moon has tended to cast a smaller shadow than the others. But the charts seem to indicate that Europa would not yet have been in position to cast its shadow on Jupiter. The transit of Io's shadow had ended several hours before we started looking, and Callisto was out of the question.

In the past when I've seen little dark dots that were in Jupiter's atmosphere, they've tended to be located on the boundaries between lighter and darker zones, rather than sitting in the middle of a light zone.

So, help! I'm confused, and the kids are congratulating each other on dis-

covering something mystifying to me. What's going on up there? Have others written about the same events?

ROBERT SCHIFFER

Judson School
Scottsdale, Ariz.

Mr. Schiffer / What you observed was not anything "new", but it was a fascinating sight reported by many readers. You saw Ganymede itself traversing in front of Jupiter. Because that moon is so large, and because it was lined up with the light zone of Jupiter (the south tropical zone), it was easier to observe than usual. Fortunately, photographer Jim Rouse caught the event on film (see page 28).

Sir / Last Christmas a friend offered me the chance to look through his telescope — an inexpensive 60mm refractor. I had never seen the moon through a telescope before. A month later I found out that the crescent object in the west was Venus, and Jupiter had to be the neatest thing I had ever seen with the four white dots, its moons.

I started going to the library and checking out armloads of books on astronomy. Some were quite hard to get through — others were more my speed. Then I received your offer in the mail to subscribe to ASTRONOMY. The issues of your magazine in front of me now are not enough — I

can't stop reading until there is nothing left to read.

I am now waiting for delivery on my own telescope. Thanks for the great magazine.

ED HEIN

Kalamazoo, Mich.

Sir / Having read the articles on the Perseid meteor shower in ASTRONOMY, I was surprised to find out that most observers only averaged 30 meteors an hour. I was out with a companion on the night of Aug. 12 and the morning of the 13th from 11:00 p.m. to 1:00 a.m. The seeing conditions were excellent until the moon came up. We each took half of the sky and counted a total of 95 meteors for the two hours, making sure we didn't mark the same one twice. The first hour before the moon came up we counted 53 Perseids and five "strays".

STEVEN WOLF

Burlington, Wisc.

Mr. Wolf / The figures mentioned in our meteor articles assume only one person is doing the observing. Two people facing in opposite directions can catch about 30 percent more meteors than a single observer. You didn't say, but one of you (the one facing Perseus) should have seen the bulk of the meteors. Next year there will be no moon so even higher rates are likely. Thanks for your observations, and keep watching.



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MEASURING STAR DIAMETERS

by
Gerrit L. Verschuur

To the unaided eye, practically everything in the sky except the sun and moon appears like a pinpoint of light. Some of these pinpoints are planets — usually the brightest ones — and the rest are stars. But the difference between planets and stars goes far beyond a mere discordance in brightness. Any small telescope focused on Jupiter, Mars, Venus or Saturn will instantly reveal a disk. We perceive another world whose clouds or rocks reflect the sun's light back to us. But that same telescope, when turned to the stars, shows nothing new. We still see pinpoints — they just look brighter in the telescope.

What about a larger telescope? Even the 200 inch Mt. Palomar giant still shows all stars the same. If we tried to measure their visual diameters, the bright ones would seem to be larger than the faint ones — but that's only an illusion caused by atmospheric turbulence and a property of optics called diffraction. The stars are simply too far away for their diameters to be measured directly.

Since no telescope on Earth is capable of revealing the tiny disk of a star, how do we do it? How can we say that Sirius is 1.8 times the diameter of the sun? Yet that statement appears in many astronomy books. How is it done?

Until recently it was educated guesswork. We know how far away Sirius is; we know its apparent brightness, and we have studied its spectrum. Using this information plus some additional assumptions about stellar evolution we get a rough estimate of the diameter. But suppose we're wrong about some of our assumptions — how can we check them? It would be reassuring if we could somehow actually measure a star's diameter.

Now, thanks to a remarkable new telescope, that elusive astronomical endeavor — measuring the diameters of dozens of stars — has finally been achieved.

The star-measuring telescope is the stellar interferometer at Narrabri in Australia. It consists

of two 20 foot wide mirrors separately mounted on "trucks" that move around a circular railroad track about 600 feet in diameter. Each of the mirrors actually is made up of 252 individual small hexagonal glass mirrors. During the day, the telescopes are driven into a garage straddling the track to protect them from sun and wind. The strange thing about these telescopes is that you can't even see very clearly with them, because of the nature of their surfaces. Having 252 separate mirrors makes the whole thing fairly rough — and in order to get a good image in astronomy, a highly polished, very smooth surface is necessary.

The stellar interferometer was not built for photographing objects in space; it was built only to measure the sizes of stars. The two large mirrors are used as "light buckets", collecting as much light as possible and focusing it to one point; each of the 252 small mirrors do this separately. The light is then focused onto a photomultiplier — a device for converting the light to an electrical signal, which in turn can be amplified (electronically magnified) and processed by a computer.

The basic principle of this interferometer is this: A light signal (a photon) from a distant star will simultaneously reach each of two telescopes located at the same distance from the star. If this is so, then we say that the light received by one

telescope is correlated with the light received by the other. Using computer circuits, the amount of correlation can be measured. If these measurements are made with telescopes separated by the maximum distance on the track, only the smallest stars will still be observed in correlation. Light from the larger stars will seem "confused" until the telescopes are pulled closer together. This method provides comparative diameters from which the actual diameters eventually can be derived.

The stellar interferometer at Narrabri is not limited by seeing or diffraction disks as single conventional telescopes are. It is only limited by how far apart the telescopes can be located so that the light can still be converted to electrical signals which can be compared in a computer. There are a lot of technical difficulties associated with such an experiment — mainly because the computer isn't only comparing the signals from the star, but also signals from the photomultiplier, the night sky, interference, etc.

R. Hanbury Brown, who spent over 10 years working on this interferometer, faced many unexpected problems in building such a complex system miles from anywhere. The scientists, in the best tradition of pioneering research, soon became adept in welding and other nonastronomical trades.

MEASURED STAR DIAMETERS

Star Name	Magnitude (apparent)	Measured Diameter (seconds of arc)	Actual Diameter (sun=1)	Luminosity (sun=1)	Temperature (degrees Fahrenheit)	Distance (light-years)
Alpha Canis Majoris (Sirius)	-1.4	0.0059	1.8	23	24,000	8.7
Alpha Carinae (Canopus)	-0.7	0.0066	24	1500	15,000	100
Alpha Bootis (Arcturus)	-0.1	0.020	23	110	9,000	37
Alpha Lyrae (Vega)	0.0	0.0032	3.0	53	25,000	27
Beta Orionis (Rigel)	+0.1	0.0025	77	55000	30,000	900
Alpha Canis Minoris (Procyon)	+0.4	0.0055	2.1	8	13,000	11.3
Alpha Orionis (Betelgeuse)	+0.4	0.054*	800*	15000	6,000	500
Alpha Eridani (Achernar)	+0.5	0.0019	8	700	33,000	118
Alpha Aquilae (Altair)	+0.8	0.0030	1.9	10	18,000	17
Alpha Tauri (Aldebaran)	+0.9	0.020	45	400	8,000	68
Alpha Scorpii (Antares)	+0.9	0.040	400	9000	7,000	400
Alpha Virginis (Spica)	+0.9	0.0087	7	1800	45,000	220
Alpha Piscis Austrinus (Fomalhaut)	+1.2	0.0021	1.8	13	22,000	23
Beta Crucis	+1.3	0.0007	13	5500	50,000	490
Alpha Leonis (Regulus)	+1.4	0.0014	4.3	160	30,000	84
Epsilon Canis Majoris	+1.5	0.0008	16	10000	45,000	680
Gamma Orionis (Bellatrix)	+1.6	0.0007	14	3700	45,000	470
Beta Carinae	+1.7	0.0016	5	100	25,000	86
Epsilon Orionis	+1.7	0.0007	40	40000	50,000	1600

*Betelgeuse varies in size and brightness irregularly over a period of years. The diameter given is the maximum. The listed magnitude is the average value.

Arcturus, Betelgeuse, Aldebaran and Antares were measured in 1920 with an interferometer attached to the Mt. Wilson 100 inch telescope. The other stars were measured with the device described in this article.



Rigel



Sun



Sirius



Vega



Regulus



Achernar



Arcturus



In order for the two mirrors to be precisely located with respect to the stars, the trucks had to be accurately driven and positioned — which meant that the tracks had to be very accurately leveled. The complexity of the experiment almost defies description. For example, the light from a star has to precisely reach each of the photomultipliers at the same time and then remain precisely in step until the signals are compared in the computer. If there is a difference of more than one thousand-millionth of a second between the two paths, the experiment fails.

About 20 years passed from the time Brown started thinking seriously about the experiment until this year, when an article containing diameters of 32 stars appeared in the *Astronomical Journal*. Twenty years seems a long time to spend measuring the diameters of a handful of stars, but such dedication seems to be part of the advance of science.

The largest diameter measured so far by the Australian interferometer is 0.0059 seconds of arc for Sirius, and the smallest is 0.0004 seconds of arc for Zeta Puppis and several other stars. These measurements are the *apparent* diameters. To find the true diameter the distance has to be included in the calculations. The nearer stars often appear larger for that reason (just like Mars looks larger than Neptune, when in reality it's the other way around). The actual diameters are included in the table.

Measuring diameters this small is not a matter of going to the telescope, pointing at the stars and taking a reading. It requires up to 50 hours of continuously tracking one star at a time, recording all the data, and then processing it for an answer. That means that 10 nights might be spent

just tracking one star and storing all the data until it is all available for processing.

Basically the measured diameters of the stars agree well with those calculated years ago. For example, Vega has an apparent diameter of 0.003 seconds of arc — just what was expected from theory.

Before the new data became available, less than a dozen diameter measurements (made early in this century with the Michelson interferometer by F. G. Pease) were available. Some of these are included in the table to give a broader cross section of star types. Unfortunately the Narrabri interferometer cannot measure many more stars than it already has, since most are too faint for the present "light buckets" (mirrors) to collect enough light to attempt the measurement. It is possible to build a larger interferometer based on the same principles, but funds are not yet available.

Does this mean that no more stellar diameters will be measured in the near future? No, because strange as it may seem, the moon can be used to measure star diameters. When a star disappears behind the moon during an occultation, the way the light signal disappears can provide information to allow an estimate of the stellar diameter. However this seemingly simple experiment is very difficult in practice. There are many irregularities on the moon's surface that make for trouble. Scintillations in the atmosphere and random signals in the telescope affect the observations. These difficulties limit the number of stars whose diameters can be measured by the lunar occultation technique to a few hundred over the next 20 to 30 years. Larger and more expensive interferometers will eventually be required for us to substantially increase our knowledge of star diameters. 

Betelgeuse

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In response to requests from our readers and schools, ASTRONOMY has just published a cumulative index to Vol. 1. This subject index covers August, September, October, November and December, 1973, which includes issue Nos. 1 through 5. Index to Vol. 1 is available for \$1.00 each, including handling and first class postage.

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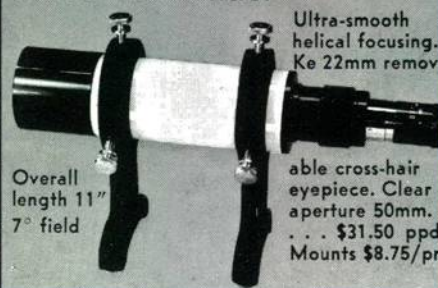
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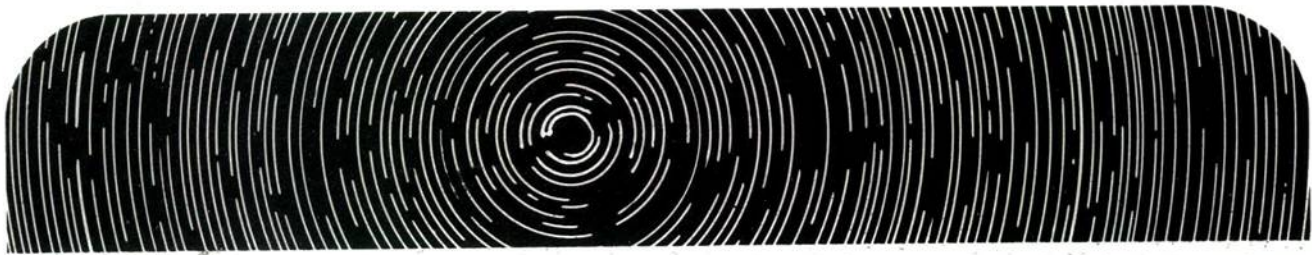
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Viewing the Partial Eclipse

On Friday, Dec. 13, 1974, a partial eclipse of the sun will be visible from every state except Alaska and Hawaii. Despite the fact that from certain parts of the country up to 70 percent of the sun will be blotted out by the moon, most of the populace will be oblivious of the event. The sun is so bright that the 30 percent of it still visible is enough to retain the illusion of full daylight.

The partial eclipse is caused by the moon passing between us and the sun — but not *exactly* between, or we would get a total eclipse. The shadow of the moon just misses Earth this time, passing about 1,000 miles above the arctic regions of our planet. The maximum amount of solar obscuration (83 percent) will be witnessed by observers on Baffin Island in northern Canada.

However, no one will be going there specifically to observe this eclipse since serious and meaningful study of the sun during an eclipse (such as coronal and chromospheric studies) can only be carried out under conditions of a total eclipse.

The major land areas of the North American continent have almost run out of their allocations of total eclipses for the balance of this century. Only two are left — one in Mexico in 1998, and one whose track sweeps over the northern plains on Feb. 26, 1979.

Since there is no reason to travel anywhere to get a significantly better view, you can watch the event from your own backyard provided appropriate precautions are taken. Unaided eye observers can fashion a makeshift filter from a roll of fully exposed black and white film devel-

oped to maximum density. Use two layers of the film for proper protection. Most telescope users are familiar with the potential danger involved in viewing the sun. But if you are a novice observer, unfamiliar with the correct procedure, it is vital that you read the following before viewing the partial eclipse of the sun.

Never look at the sun through your telescope unless it is properly protected. There are a few rare exceptions to this rule such as times when the sun is dulled by haze near sunrise and sunset (see below), but beginners are urged not to attempt unfiltered solar observations. Many small telescopes come equipped with a small filter designed to be placed at either end of the eyepiece — either capped on the end closest to the eye, or screwed or clipped into the end that fits into the focusing sleeve. These filters are the least desirable “protection” to use when observing the sun. They heat up very quickly because of the concentrated solar radiation near the focus of the telescope. After a few minutes they will crack or melt allowing intense radiation to suddenly hit the eye of the observer. The editors of *ASTRONOMY* do not recommend the use of these eyepiece filters!

Inexpensive full aperture filters for use over the front of the telescope, before the light ever enters the lens (or in the case of a reflecting telescope, before the light goes down the tube), permit safe, direct viewing of detail on the sun. These filters reduce the sun's intensity to about 1/100,000 of its normal brightness. (Full aper-

ture filters are available from some of the suppliers that advertise in this magazine.) If you do not have such a filter or choose not to get one, the disk of the sun can be projected onto a screen thereby allowing its image to be viewed by the telescope operator and several onlookers. The projection method provides less detail for solar surface observation but is fine for a partial eclipse.

If you choose to project the image of the sun don't use an orthoscopic eyepiece or any eyepiece that contains multiple lenses cemented together. The concentrated heat from the sun will damage expensive cemented eyepieces. The safest way to be sure that you are not using this type of eyepiece is to use your lowest power eyepiece which is almost invariably the simple, noncemented two-element type. One drawback with the projection method is that the heat generated by larger aperture telescopes (over six inches) becomes so great that something even brushing in front of the focus of the telescope is almost instantly set in flames. It's a good idea to stop down large telescopes with a piece of cardboard with a three to four inch hole in it. The eliminated light really isn't necessary.

The time and duration of the eclipse varies across the country. The table on this page may not list your location, but you can use the data for the city nearest you — it won't be off by more than a few minutes. If one region of the country could be singled out as favorable, it would be New England where about 70 percent of the sun

OBSERVING DATA FOR PARTIAL SOLAR ECLIPSE

DEC. 13, 1974

City	Eclipse Begins	Maximum Eclipse	Eclipse Ends
New York (EST)	9:26 a.m.	10:57 a.m. (65%)	12:32 p.m.
Pittsburgh (EST)	9:17 a.m.	10:44 a.m. (62%)	12:18 p.m.
Atlanta (EST)	9:11 a.m.	10:31 a.m. (49%)	12:01 p.m.
Chicago (CST)	8:10 a.m.	9:31 a.m. (60%)	11:00 a.m.
New Orleans (CST)	8:08 a.m.	9:18 a.m. (38%)	10:38 a.m.
Kansas City (CST)	8:05 a.m.	9:18 a.m. (51%)	10:41 a.m.
Denver (MST)	7:03 a.m.	8:07 a.m. (43%)	9:18 a.m.
	(sunrise - 7:17 a.m.)		
Salt Lake City (MST)	7:04 a.m.	8:03 a.m. (39%)	9:07 a.m.
	(sunrise - 7:48 a.m.)		
Los Angeles (PST)	6:11 a.m.	6:53 a.m. (18%)	7:37 a.m.
	(sunrise - 6:54 a.m.)		
San Francisco (PST)	6:11 a.m.	6:54 a.m. (23%)	7:42 a.m.
	(sunrise - 7:21 a.m.)		



Diagram by Victor Costanzo

The shadow of the moon just misses Earth on Dec. 13, 1974, so no total eclipse of the sun will be seen from anywhere on

the planet. However, the penumbral shadow - the partial eclipse shadow - will be cast over most of North America.

will be wiped out at noon on Dec. 13. Less fortunate are observers in Oregon and Washington, where most of the eclipse will be over before sunrise.

Residents of the northern plains states, the Rocky Mountain states, the southwest area and California will have a special treat if weather conditions cooperate: The sun will rise while the eclipse is in progress. Instead of the usual orange ball peeking over the eastern horizon, the solar disk will have a "bite" carved out of its left side. Since it is sometimes possible to view the rising sun without eye protection (due to atmospheric obscuration), this has the potential of being a truly dramatic event for astronomy enthusiasts in the west. Photography of the sun at this time may be possible without special filtration — but do not even attempt photography unless the sun is sufficiently reddened by haze so that you can easily and comfortably look directly at it with the unaided eye. This condition is likely to exist *only* at sunrise, and *only* in locations where a deeply reddened sun is normal at sunrise and sunset in December.

If you are certain that the sun's brilliance is

adequately muted, then unfiltered telephoto or telescopic shots showing the eclipsed sun rising over a distant landscape are possible. Remember, *you must be certain* the horizon haze is thick enough to allow direct, comfortable viewing with the unaided eye. Check this *before* attempting unfiltered photography. For solar photography and visual observing under all other circumstances, proper filtration is absolutely essential.

Telephoto lenses must be treated in the same category as telescopes when considering proper filters. Polarizing filters and neutral density filters used for photography *are not* suitable for viewing the sun since they transmit dangerous infrared energy. Once you are properly set up for photography take a number of exposures at different shutter speeds to ensure at least one good result.

For the rest of us who simply care to watch and enjoy, this is a leisurely event requiring little effort. One final word: If you are at all unsure you are using the necessary precautions for solar observation, *don't take any chances*. Project the telescope's image on a white card to avoid any possibility of danger. 

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet

α Alpha	η Eta	ν Nu	τ Tau
β Beta	θ Theta	ξ Xi	υ Upsilon
γ Gamma	ι Iota	$\omicron$ Omicron	ϕ Phi
δ Delta	κ Kappa	π Pi	χ Chi
ϵ Epsilon	λ Lambda	ρ Rho	ψ Psi
ζ Zeta	μ Mu	σ Sigma	ω Omega



MAGNITUDES

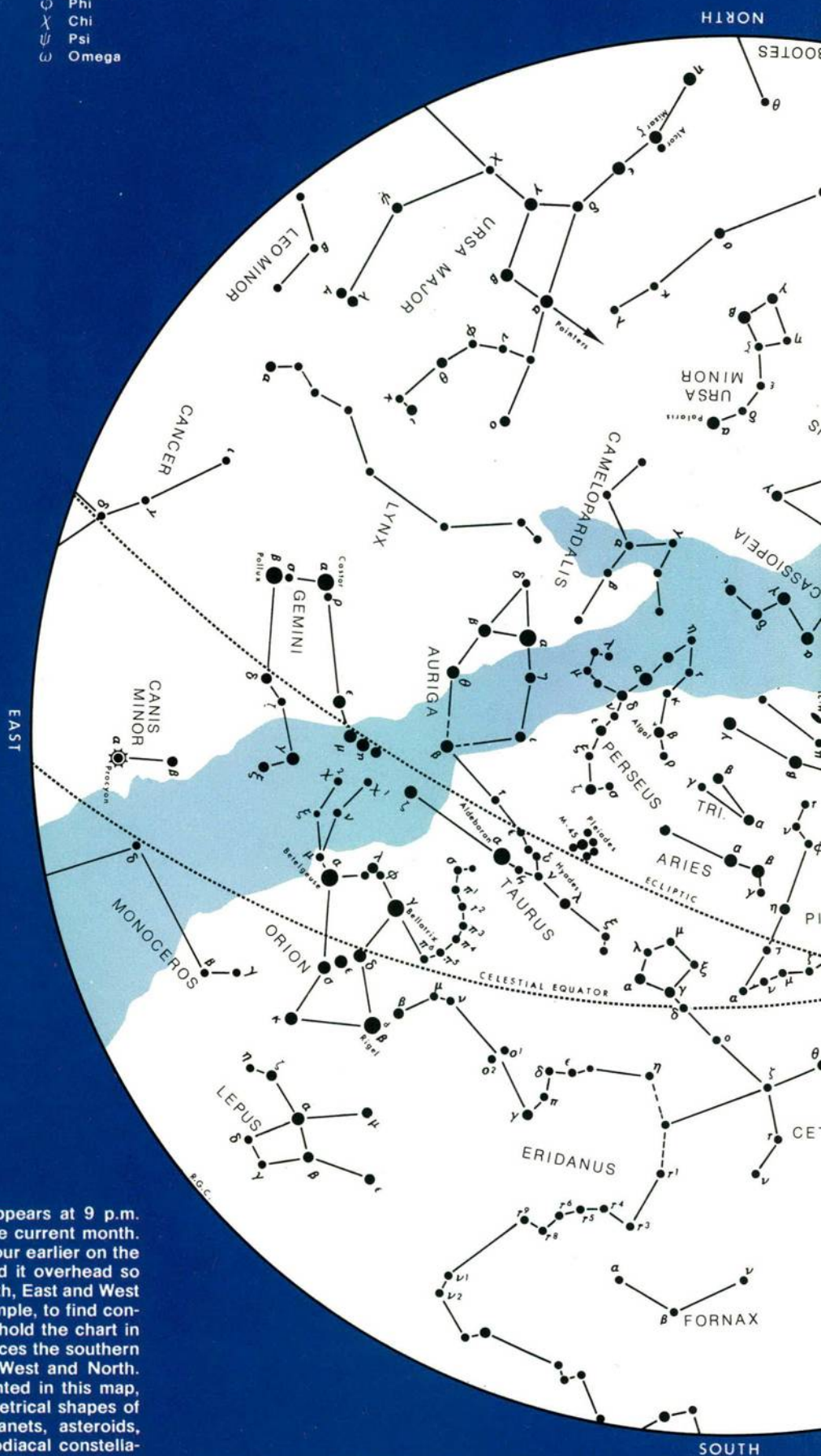
- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars

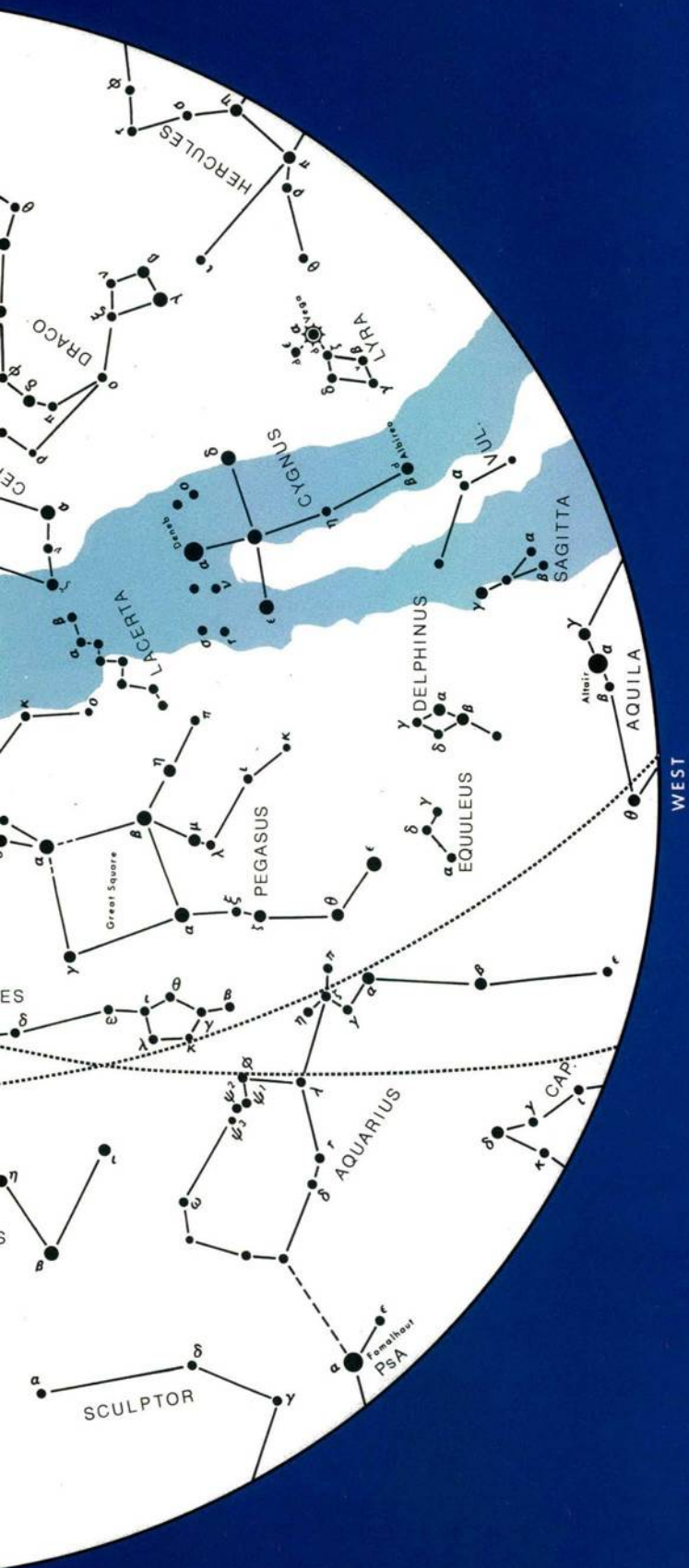
Star Dome approximates the sky as it appears at 9 p.m. Local Standard Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

DECEMBER



Map Centered on 43° North Latitude

STAR DOME



Christmas and stars — the two automatically go together. Christmas cards are graced with illustrations of stars illuminating a tranquil scene; the legendary Star of Bethlehem mentioned in the Bible always pops up for re-examination at this time of year; and for some reason, the winter skies themselves seem to urge wandering eyes to stray skyward to absorb some of the beauty.

The 1974 December sky is unusually bright this year due to the presence of two planets in addition to the brilliant constellations Orion, Auriga and Gemini in the evening sky. Brilliant Jupiter is in the dim constellation Aquarius, and Saturn is within the boundaries of Gemini. If you aren't sure where to look for them you can check the positions of these two planets in the map in *Sky Almanac* on pages 30 and 31. Aquarius and Gemini are shown there as well as on the map on this page.

Except for Jupiter, the south and southeast seem practically devoid of stars; yet it is in this area that some of our nearest stellar neighbors are located. The constellation Eridanus (pronounced e-RID-dan-us), the celestial river, dates back to the cradle of civilization in what is now Iraq. Eridanus appears to have been thought of as the sky counterpart to the Tigris and Euphrates rivers. From the northern hemisphere we only see about half of this straggling constellation — the longest in the sky.

Beta Eridani (also known as Cursa) is the brightest star in Eridanus that is visible from the United States. The configuration trails down below the horizon after it swings around the nearly invisible constellation Fornax (the furnace) and ends up in the deep southern sky with the first magnitude star Achernar (ACHE-er-nar). The southern extent of Eridanus is shown on one of the maps in the lead feature in this issue. As told in that article, the largest concentration of nearby stars like our sun exists in this part of the sky — largely hidden from our view, here in the northern hemisphere. The stargazers who first named Eridanus certainly had no idea that it did hold an unusual proportion of sun-type stars. Nor did they have any idea what the stars actually are. The distances of the stars is something that was equally unknown and is still the subject of intensive research at several major observatories.

Today we can sit back in our armchairs and easily acquaint ourselves with a multitude of celestial statistics. When we look at Beta Eridani, for



Photograph by Leo C. Henzl Jr.

Twin swarms of stars over 7,000 light-years distant are just visible to the unaided eye in the constellation Perseus.

Called simply the "double cluster", this object can be located by using the map on page 52.

example, we are looking across 78 light-years of space; 78 light-years is equivalent to 460 trillion miles — a truly incomprehensible number.

Apparently very close to Beta Eridani is Orion's superbrilliant Rigel, a star that ranks as one of the brightest in the entire Milky Way galaxy. It shines with the equivalent force of 55,000 suns, a brilliance that is somewhat muted by its 900 light-year distance. It is only the colossal stellar powerhouses that remain visible at such distances. A star like the sun at Rigel's distance would be 10th magnitude — an inconspicuous, unimportant speck in the field of view of the earthbound astronomy enthusiast's telescope.

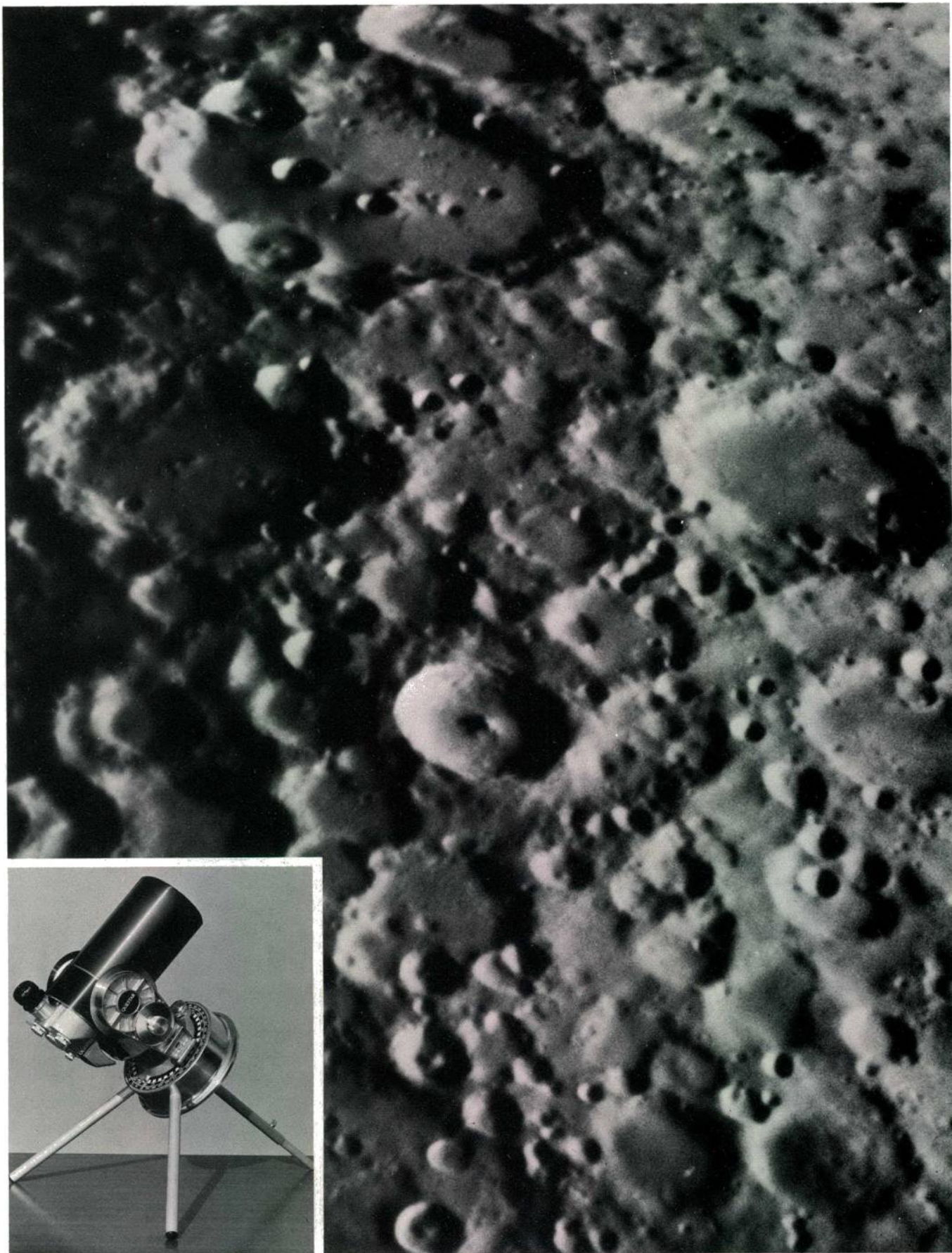
A question that you may have after reading this far is, "It's all very interesting to talk about the distances to these various stars. But when I go out to look for them, I can't find anything that I can identify with certainty."

If this is your problem, it can be remedied by locating the brightest star groupings in the sky. Every few months we point them out and also describe how to use the brighter groups — like Orion — to locate the fainter constellations. We'll continue to do that in the months ahead. But, for this month may we make a suggestion?

In almost every city in the U.S., there is a

planetarium. Some cities have major planetariums with dynamic star shows and sophisticated projection systems that required outlays of millions of dollars. Generous donors have been benefactors for such institutions in major cities such as New York, Chicago and Philadelphia. There are over a dozen of these major planetariums in the U.S. and several hundred smaller ones that are open to the public. Do yourself a favor: If you don't already know if there is a planetarium in your town, check with your local museum or university. You may find that there is a planetarium that you weren't even aware of in your town or in a city close to you. There may be public presentations that you can attend.

Try it — go to a planetarium next chance you get, especially during the Christmas season when most of them have programs which deal with the scientific interpretation of the possible nature of the Biblical Star of Bethlehem. These programs almost always include a section on identification of stars in the nighttime sky. Underneath the dome of a planetarium the sky is re-created in a way that is impossible on the flat page of a book or magazine. You may find that the artificial sky of the planetarium is the perfect way to begin to learn your way around the real sky. 



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QUESTAR

BOX 80, NEW HOPE, PENNSYLVANIA 18938

PUBLISHER'S MEMO

With this issue we welcome Raymond Vilard to the Milwaukee staff of ASTRONOMY magazine. As assistant editor, he's eagerly gearing up for our regular 80 pager starting with the January 1975 issue. Ray comes to us with a wealth of valuable experience: He received his masters degree in 1973 from Boston University in science communications, concentrating in astronomy. Prior to joining ASTRONOMY, Ray was at the Boston Museum of Science — Charles Hayden Planetarium where he assisted in writing, producing and presenting planetarium programs for the general public and grade school children. He also designed and taught an astronomy course for teenagers.

Remember to look for the changes in ASTRONOMY next month — among other things, it will be noticeably fatter!

No doubt you have already discovered the curious bulge in ASTRONOMY's centerfold this month. It's a survey questionnaire which is vital to our future direction and growth. It is a tool — your tool, your voice — to tell us what we're doing right and what we're doing wrong. A magazine does not determine its own direction and future; it cannot exist in a vacuum unconcerned with the needs and wants of its readers. A magazine exists because it satisfies a need. The need ASTRONOMY is trying to satisfy is the need for a graphic publication

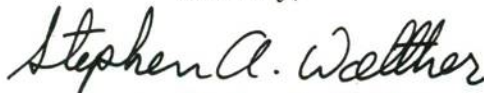
that appeals to a popular level audience. In order to determine how well (or badly) we are satisfying the need as we interpret it, we earnestly need definitive, in-depth feedback from you, our only reason for existing. All of you, in one grand eloquent voice, sit in judgement on us every issue and have both the authority and power to sentence ASTRONOMY to life or death.

We ask you then to exercise your authority as a reader, and help us make ASTRONOMY everything you want it to be. Take 30 minutes of your time to answer all questions in the survey — please determine the future of your magazine.

To our new subscribers who qualify for the Antares Lithograph: We have experienced two major delays. First, production has been slow because of our insistent demand to create the highest quality product possible. Second, delivery of mailing tubes has been delayed due to a mechanical breakdown. If you have not yet received your lithograph please be patient just a little longer. Your lithograph will arrive before Christmas.

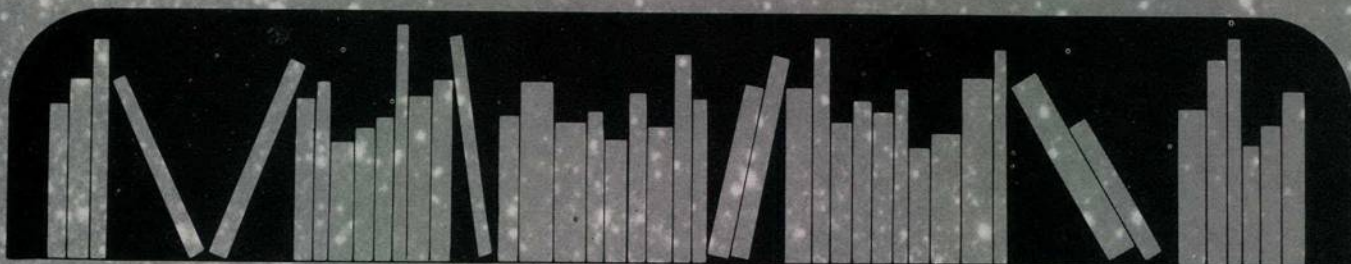
Due to innumerable problems encountered with our spring circulation contest, it will no longer be possible to honor our two month subscription extension for every new subscriber you bring us. This extension policy terminates effective with mail received on Dec. 5, 1974.

Sincerely,



Stephen A. Walther
Publisher

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Act of August 12, 1970; Section 3685, Title 39, United States Code) 1. Title of publication: ASTRONOMY Magazine. 2. Date of filing: September 12, 1974. 3. Frequency of issue: monthly. 4. Location of known office of publication: 757 N. Broadway, Suite 204, Milwaukee, WI 53202. 5. Location of the headquarters or general business offices of the publishers: 757 N. Broadway, Suite 204, Milwaukee, WI 53202. 6. Names and addresses of Publisher, Editor and Managing Editor: Publisher, Stephen A. Walther, 820 E. Mason St., Milwaukee, WI 53202; Editor, Terence Dickinson, 143 Ludwig Avenue, Dousman, WI 53118; Manager/Editor, Stephen A. Walther, 820 E. Mason St., Milwaukee, WI 53202. 7. Owner: Astro-Media Corp., 757 N. Broadway, Suite 204, Milwaukee, WI 53202, whose owners are: Stephen A. Walther, 820 E. Mason St., Milwaukee, WI 53202; David L. Walther, 2403 E. Newberry Blvd., Milwaukee, WI 53211. 8. Known bond holders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages or other securities: none. 9. For optional completion by publishers mailing at the regular rate (Section 132.121, Postal Service Manual): permission requested. 10. For completion by non-profit organizations authorized to mail at special rates (Section 132.122, Postal Manual): does not apply. 11. Extent and nature of circulation: 11A Total no. copies printed (net press run): average no. copies each issue during preceding twelve months, 26,353; single issue published nearest to filing date, 835. 2. Mail subscriptions: average no. copies each issue during preceding twelve months, 22,930; actual no. of copies of single issue published nearest to filing date, 30,908. 11C Total paid circulation: average no. copies each issue during preceding twelve months, 23,593; actual no. of copies of single issue published nearest to filing date, 31,743. 11D Free distribution by mail, carrier or other means: 1. Samples, complimentary, and other free copies: average no. copies of each issue during preceding twelve months, 331; actual no. of copies of single issue published nearest to filing date, 294. 2. Copies distributed to news agents, but not sold: average no. copies each issue during preceding twelve months, 0; actual no. of copies of each issue during preceding twelve months, 0. 11E Total distribution (sum of C and D): average no. copies of each issue during preceding twelve months, 23,924; actual no. of copies of single issue published nearest to filing date, 32,035. 11F Office use, leftover, unaccounted, spoiled after printing, average no. copies each issue during preceding twelve months, 2,429; actual no. of copies of single issue published nearest to filing date, 3,386. 11G Total (sum of E and F - should equal net press run shown in A): average no. copies each issue during preceding twelve months, 26,353; actual no. of copies of single issue published nearest to filing date, 35,421. I certify that the statements made by me above are correct and complete. (Signed) Stephen A. Walther, Publisher.



ASTRONOMY REVIEWS

The UFO Experience

by J. ALLEN HYNEK

288 pages, hardcover, \$6.95
Henry Regnery Company (1972)
(Ballantine paperback, \$1.50)

Few people have been associated with the unidentified flying object (UFO) "problem" longer than J. Allen Hynek, director of Dearborn Observatory at Northwestern University. Hynek became scientific consultant to the U.S. Air Forces' official UFO office, Project Blue Book, in 1952 — a position that made him aware "of some very interesting cases, most of which were submerged in a veritable quagmire of nonsense reports".

From that time until now, Hynek has been one of the few scientists who have spent at least some time actively pursuing the UFO phenomenon. He states flatly, "No scientist who examines the subject objectively can claim for long that UFOs are solely the products of simple misidentification of normal objects or events."

Unlike most books on UFOs, this one does not seek to chronicle how the sightings prove that spaceships from other planets are here. On the other hand, this possibility is not rejected either. This is, in our opinion, the most level headed assessment of the UFO phenomenon yet published. Hynek seems to be truly interested in getting to the bottom of it. He categorizes the various types of sightings and gives examples of each (including a good section on the Hill encounter which is mentioned in this month's feature article), and then suggests a course of action for future evaluation. (Hynek has already taken one of his own suggestions to heart by establishing the Center for UFO Studies, described in detail in the March 1974 issue of ASTRONOMY.)

Yet he admits, "After more than 20 years association with the problem, I have few answers and no viable hypothesis." Perhaps the efforts of Hynek or someone influenced by him will eventually shed light on what is truly an unsolved dilemma of 20th century science. In the meantime, read this book!

(For a primer to the UFO problem, watch your local NBC station on Sunday evening, Dec. 15, 1974.)

UFO's — A Scientific Debate

edited by CARL SAGAN and
THORNTON PAGE

340 pages, hardcover, \$12.50
Cornell University Press (1972)

An intriguing conviction seems to have swept across this country and many other parts of the world in recent years. The conviction is this:

Beyond Earth there exist creatures of intelligence and abilities far superior to our own. On their planets they have done essentially what we have, but have had time to evolve a technology and accrue a wealth of knowledge that has enabled them to explore beyond their own planetary system. One of the planets that they have visited is Earth.

Basically that paragraph summarizes the "belief" of a vast number of people. Whether it resulted from, or was spawned by a quarter century of the so-called UFOs is a moot point.

Opinions on UFOs among scientists vary greatly. Donald H. Menzel of Harvard Observatory maintains that UFOs are a myth created to explain something we do not understand, and is convinced all sightings can be explained in conventional terms provided enough data on each case is available. On the other hand, the late James McDonald stressed that "the UFO problem, far from being the 'nonsense problem' it has been labeled by many scientists, constitutes an area of extraordinary scientific interest."

Both of the views above and a variety of those in between are found in *UFO's — A Scientific Debate*. This volume is basically a collection of lectures given at a 1969 symposium on UFOs sponsored by the American Association for the Advancement of Science.

Because of the large variation in the convictions of the 16 scientists who contributed, and the difficulty of giving an "objective" review, we will recommend this book as "must" reading on the subject for the following reasons: There are very few books on UFOs that express the views of more than one person, and for this reason alone, this book is a valuable contribution to the field. Secondly, it contains articles by some scientists whose opinions on the subject are not in print anywhere else. And finally, it was skillfully edited to make it intelligible to the nonscientist.

Flying Saucers and Physics

by STANTON T. FRIEDMAN

17 pages, paperback, \$1.00

Ufology and the Search for ET Intelligent Life

by STANTON T. FRIEDMAN

21 pages, paperback, \$1.00
UFO Research Institute *

"After 15 years of study and investigation, I am convinced that the evidence is overwhelming that Earth is being visited by extraterrestrial vehicles. In other words, *some* UFOs are other civilizations' spacecraft," says nuclear physicist and UFO researcher Stanton Friedman in *Flying Saucers and Physics*. There certainly is no doubt about his position on the subject!

But Friedman is no nut, as unfortunately some so-called "UFO researchers" definitely are. He has a solid background of physics which gives him sound ammunition in his attempts to demolish the arguments of those whose views he opposes — a process that occupies much of the text of these two booklets.

To try to be as objective as possible, you must not only read Friedman's arguments but also the book or article he is refuting. He supplies complete references to enable the reader to do this. (Indeed, the large bibliographies make these booklets worth the money for that feature alone.)

In both of these 20,000 word booklets Friedman winds his way through a series of topics that really hit the core of the UFO problem. He asks, and then proceeds to answer such questions as: Can "they" get here from there? Can UFOs maneuver the way they are reported to — apparently defying the laws of physics? The "answers" provide stimulating reading.

Once again we will leave the reader to make his own judgements. If you digest all the books reviewed on this page you will be exposed to opinions from experts with differing backgrounds and widely differing views on this volatile subject. Friedman now spends full time lecturing on and researching the subject of UFOs. He deserves to be heard — and read.

* For sale by UFO Research Institute,
P.O. Box 941, Lawndale, Calif. 90260.



CONSTELLATION CLOSE-UP

PERSEUS

by

Thomas C. Bretl

Every summer, during the second week in August, people all over the world greet the annual return of the famous Perseid meteors. Even for those who pay little attention to the night sky

during most of the year, this is "the time of the shooting stars". There is something particularly appealing about these celestial wanderers as they plunge to a fiery death in Earth's atmosphere.

TABLE OF OBJECTS IN PERSEUS

Double Stars					
Star	Mag.	Sep.	Colors	R.A.	Dec.
η	3.9 - 8.6	28"	White, blue	02 ^h 49 ^m	+55°47'
ζ	2.9 - 9.4	13"	White	03 ^h 53 ^m	+31°49'
ϵ	3.0 - 8.1	9"	Green, blue	03 ^h 56 ^m	+39°57'
Open Clusters					
NGC	Mag.	Size	R.A.	Dec.	
869	4	35'	02 ^h 17 ^m	+57°02'	} "Double Cluster"
884	5	35'	02 ^h 21 ^m	+57°00'	
957	7	10'	02 ^h 32 ^m	+57°25'	
1039 (M-34)	6	18'	02 ^h 40 ^m	+42°40'	
1245	7	30'	03 ^h 13 ^m	+47°09'	
1342	7	15'	03 ^h 30 ^m	+37°15'	
1444	6.5	4'	03 ^h 48 ^m	+52°35'	
1513	9	12'	04 ^h 08 ^m	+49°27'	
1528	6	25'	04 ^h 13 ^m	+51°11'	
Nebulae and Galaxies					
NGC	Type	Mag.	Size	R.A.	Dec.
649-650 (M-76)	Planetary	12	2' x 1'	01 ^h 40 ^m	+51°25'
1023	Galaxy	11	4' x 1'	02 ^h 39 ^m	+38°57'

Epoch 1970



Photograph by Leo C. Henzl Jr.

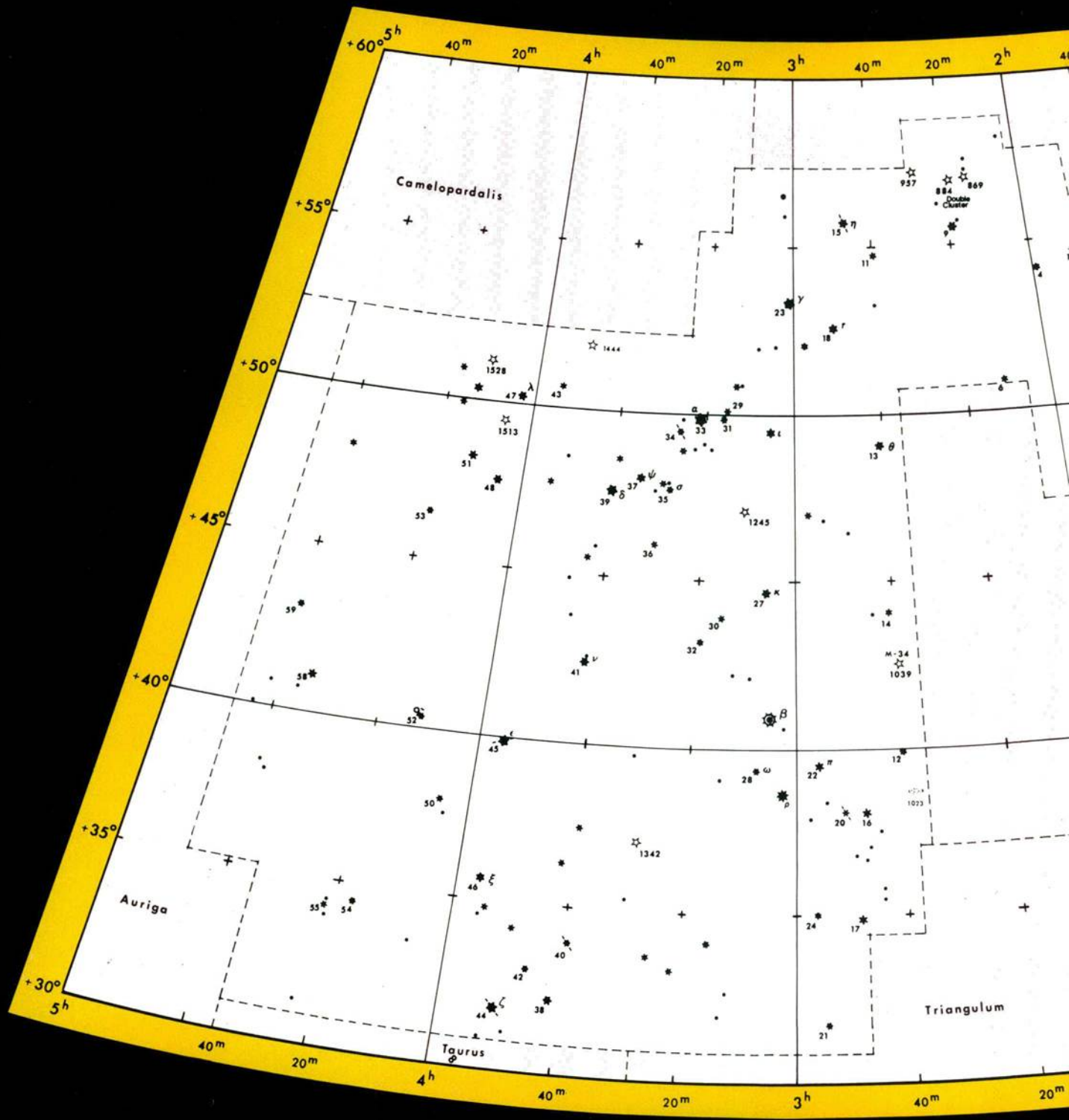
Perhaps it is their apparent spontaneity. Although somewhat predictable as part of a swarm, the individual meteor gives no warning of its final, silent streak across the star filled sky. It appears so suddenly and disappears so quickly that we are hardly even aware of its presence before it is gone forever.

Just as the excitement of anticipation sustains the observer's patience as he awaits the sudden flash of a shooting star, so does the equally exciting prospect of "discovering" a beautiful star cluster or colorful double star sustain him in his search for the deeper sky objects associated with Perseus. The same joy that comes with the unexpected sight of a brilliant fireball also comes with the recognition of an elusive nebula as it is finally brought within your telescopic field of view. The fireball, to be sure, makes a more dramatic entrance upon the celestial stage — but the nebula enjoys a much longer "run", and can be brought back on such nights for encore after encore.

Perseus, in particular, contains a wide variety of telescopic attractions that are both exciting to find for the first time and well worth observing over and over again. Heading the list is a pair of exquisite clusters catalogued as NGC-869 and NGC-884 — but more popularly known as the double cluster in Perseus. Clearly visible to the naked eye as a single fuzzy spot near the Perseus-

Cassiopeia border, this pair is so extraordinary in a telescope that no words can adequately describe the view. Each cluster is over 30 minutes of arc in diameter and contains more than 300 individual stars; together they form an unbelievably rich stellar field which extends for nearly two full degrees. (A full page photo of the two clusters appeared on page 17 of last month's issue.) Their member stars range in magnitude from 7 to 14, and any telescope — regardless of size — resolves countless numbers of them in its own special way. As James Muirden wrote in *The Amateur Astronomer's Handbook*, "a low power reveals two brilliant open clusters, each larger than the moon, set side by side against a background granular with faint stars. This is a superb object, one to which the observer returns again and again; one never tires of surveying this dazzling array of suns, and the only pity is that few telescopes can include both clusters fully in the same field of view."

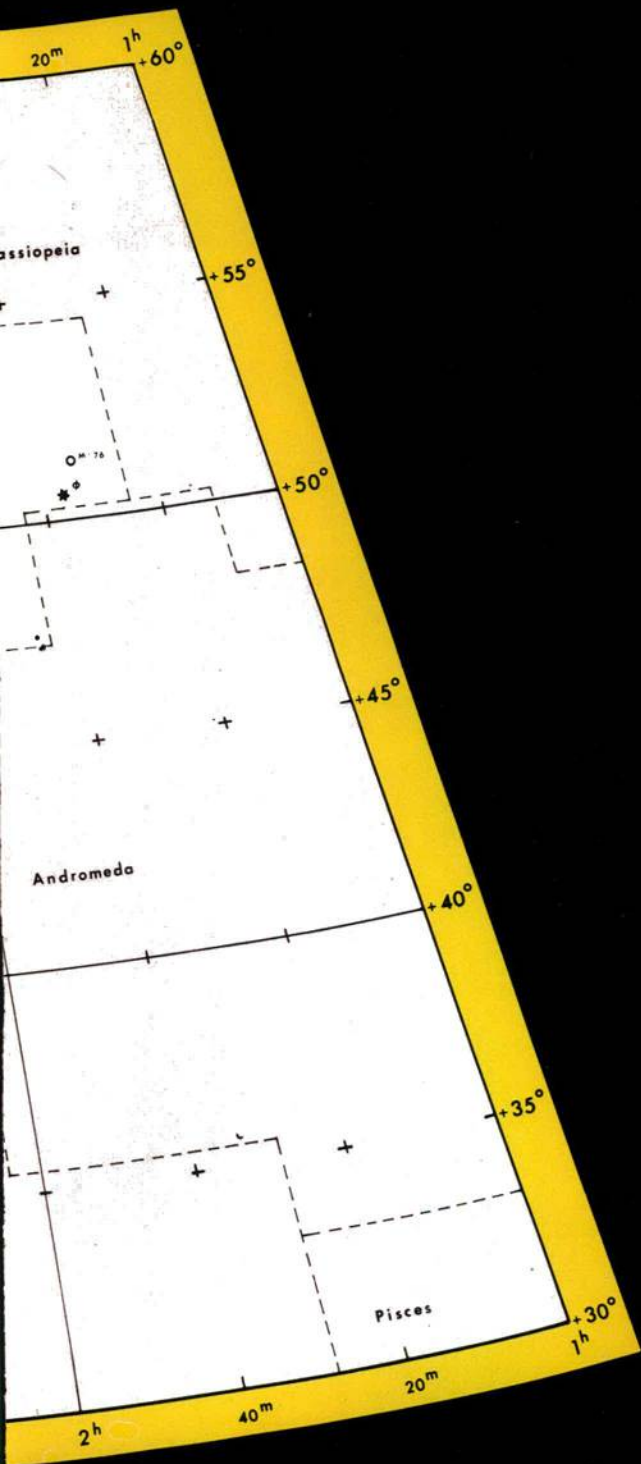
Overshadowed by its famous "double neighbor" to the north — but a fine object in its own right — is M-34, another large galactic cluster. This rather loose, scattered group of more than 90 stars lies near the western edge of the constellation; under ideal conditions it, too, is just visible to the naked eye. With many bright stars and a beautiful surrounding field, it is an especially im-



Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula ☁ Double Stars ★ Variable Stars ⚡

Galaxies ☾ Planetary Nebula ⊙ Open Star Clusters ☆ Globular Clusters ⊕



pressive sight when viewed under low magnification or in a richest-field telescope.

For nebula hunters, Perseus offers two rather faint objects from which to choose. NGC-1023, an 11th magnitude galaxy, is located about four degrees south of M-34 — while M-76, a 12th magnitude planetary nebula, lies just within Perseus' boundaries less than one degree from Phi Andromedae. M-76 consists of two small hazy patches of light which appear to be in contact (each "patch" has been assigned its own number in Dreyer's *New General Catalogue*). Its overall shape is somewhat reminiscent of the much larger and brighter M-27, and thus it is sometimes called the "little dumbbell". Because of its proximity to Phi, it should not be difficult to find — and its unique shape certainly makes it a worthwhile target.

Several individual stars in Perseus are also of considerable interest. Almost marking the radiant of the Perseid meteor shower, for example, is Eta Persei — an easy, but attractive double star. Far to its south is Zeta, a much more difficult pair which should prove a stiff test for a two or three inch telescope. By far the best known star in Perseus, however, is Algol (Beta Persei), one of the most famous of all the variable stars.

Algol does not actually physically change its light output. Instead it is a close double star system with a chance alignment that allows us to see a stellar eclipse. For about two hours every 2 days 21 hours, we can watch Algol's brightness drop dramatically from magnitude 2.1 to 3.3 as the large dull member of this stellar duo eclipses the brighter star. It's fun to observe it on successive nights and watch for the conspicuous drop in brilliance that occurs regularly without fail. For comparison purposes you can use both Eta and Zeta, together with Alpha Persei (magnitude 1.9) and Gamma Andromedae (magnitude 2.3).

As you can see, Perseus contains objects of both precise regularity and complete randomness. You can follow the clocklike variations in the brightness of Algol or look forward to the exciting spontaneity of the Perseid meteors. But on clear, dark December evenings, perhaps it is the fine collection of open clusters to be found here which most captivates our attention. As T. W. Webb wrote, "here again we enter upon one of the most splendid portions of the galaxy. Night after night the telescope might be employed in sweeping over its magnificent crowds of stars...." 

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FOR SALE — "Across the Space Frontier" by Von Braun, Whipple, Ley, et. al. and illustrated by Bonestell, Freeman and Klep (1952). Price: \$10.00. Also "The Exploration of Space" by Clarke (1952). Price: \$10.00. Write John Lulves, 192-B Clubhouse, King of Prussia, PA 19406.



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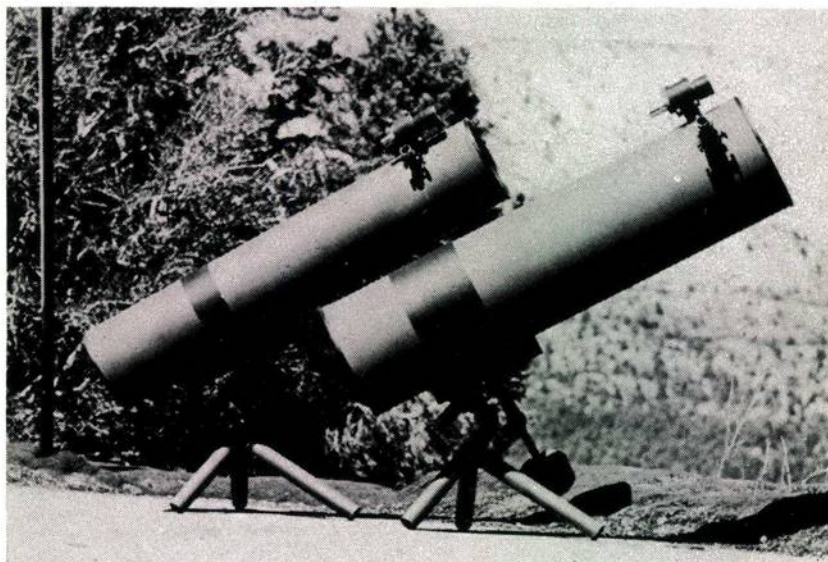
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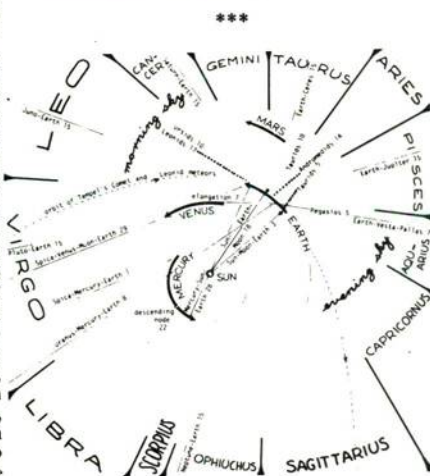
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ASTRO-NEWS

Latest News From the World of Astronomy

Mercury - Punched, Cooked and Shriveled

A gigantic chunk of space debris 50 miles across slammed into the planet Mercury about four billion years ago producing one of the largest surface features of any planet in the solar system. The scar of the ancient impact is still preserved on the virtually airless Mercury as an 800 mile wide basin with ramparts up to 10,000 feet high. Thanks to new information gained on Mariner 10's second visit to Mercury on Sept. 21, 1974, astronomers are now

almost certain this theory of the origin of the so-called Caloris Basin is correct (see photo on next page).

Mariner 10 sailed over Mercury's sunlit southern hemisphere during its second trip to the smallest planet. The rendezvous was accomplished by an unprecedented precision maneuver nine months ago during Mariner's first visit to Mercury. At that time, the spacecraft was targeted to skim only 460 miles above the planet. Mercury's

gravity altered the craft's trajectory and sent it into a six month orbit around the sun — an orbit that was precise enough to produce the Sept. 1974 encounter.

While Mariner 10 was making one circuit of the sun, Mercury made two. Due to its ponderous rate of rotation, the inner planet spun only once on its axis during that time so Mariner scientists had to be content with viewing the same side of the planet they saw the first time around. However, they viewed some areas not previously seen in detail because Mariner passed over the planet's night side on the historic first encounter.

Combining the 500 Mariner 10 photos of Mercury with the 2,000 returned during the spacecraft's first visit to the planet last March, scientists have pieced together detailed maps of more than 1/3 of the 3,030 mile diameter world. The photos show conclusively that the impact that produced the Caloris Basin was so powerful that it sent a shock wave through the entire planet, violently jumbling the surface terrain at a point opposite the impact. Such a titanic blow is equivalent to a trillion times the force that created the famous mile wide meteor crater in Arizona.

It is calculated that the big impact lifted the planet's far side 30 feet and then brutally shook it with "after-shock" quakes. From crater counts and comparisons with lunar features, the Caloris Basin is believed to be between 3.5 and 4.0 billion years old.

Earth may have been subjected to similar collisions early in the history of the solar system, but no evidence of them remains. Our planet's unique blanket of deep oceans and constantly drifting continents long ago obliterated the marks of ancient impacts.

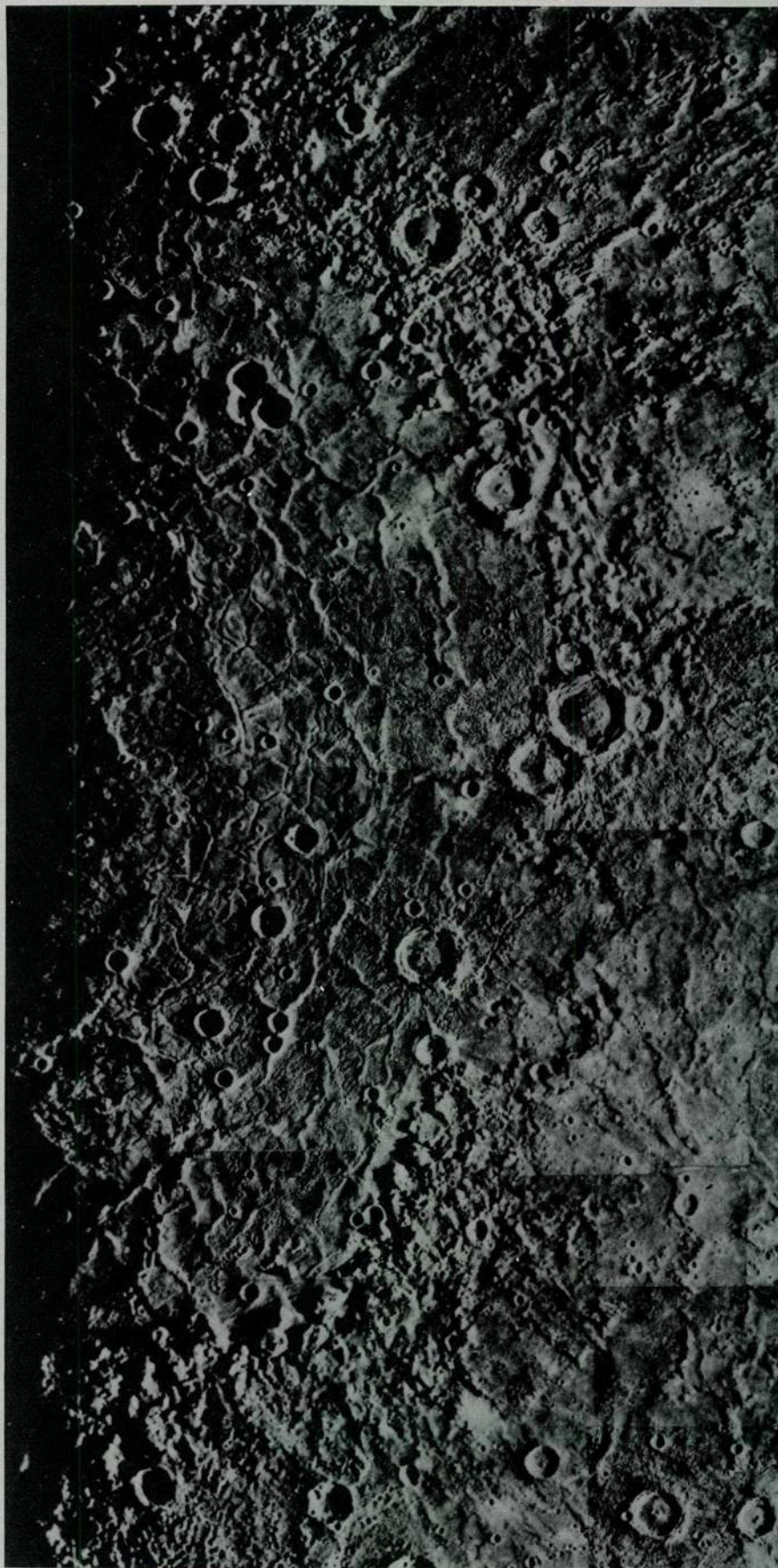
The moon, however, does still have its scars of that savage era, and two of

Mercury continued on page 58



NASA Photograph

Mercury's south pole was photographed by one of Mariner 10's television cameras as the spacecraft made its second close flyby of the planet on Sept. 21, 1974. The pole is located inside the large 110 mile diameter crater on Mercury's limb (lower center). The crater floor is shadowed and its far rim, illuminated by the sun, appears to be disconnected from the edge of the planet. The stripe across the top is an artifact introduced during computer processing. The picture was taken from a distance of 53,200 miles, less than two hours after Mariner 10 reached its closest point to the planet.



NASA Photograph

The colossal Coloris Basin, over 800 miles across and scarred by smaller craters and jumbled ridges, is the remnant of the impact of a 50 mile wide planetoid that hurtled into Mercury four billion years ago. The basin was named Coloris (hot basin) because this side of Mercury alternately faces the sun when the planet is nearest our star. The temperatures in the basin at those times must exceed 700 degrees.

Mercury *continued from page 57*

them — Mare Imbrium and Mare Orientale — are nearly as large as Mercury's Caloris Basin. They too seem to have affected surface features at their respective antipodal points (the point on the opposite side of the sphere) in a way similar to the "jumbling" caused by the impact on Mercury.

These observations strengthen the belief that virtually all of the craters and many of the other structures on the smaller planets and satellites of the solar system are the result of impacts during the first billion years of the solar system's history. (The solar system, including Earth, is believed to be 4.6 billion years old.)

One difference noted on Mercury is the "compressional scarps", not seen on the moon or Mars. These ridges, up to 8,000 feet high and 400 miles long, are suspected of being the result of a slight shrinkage of Mercury's outer layers — something like the wrinkles on a dried apple (see photo in last month's *Astro-News*).

In comparing the three similarly sized worlds of the inner solar system — the moon, Mercury and Mars — there are so many subtle differences among them that theories on the origins of all three are far from complete. Mercury, for example, got treatment the others largely avoided. Because of its nearness to the sun — 36 million miles compared to 93 for Earth-moon and 141 for Mars — Mercury got "cooked" back around the time all the planets were forming. Virtually all of the lighter elements were blasted away from the planet, leaving a small dense ball of rock and iron. Somehow the heavy elements drifted to Mercury's core leaving a moonlike outer layer but an Earth-like central region.

If all goes well, Mariner 10 will return for a third visit to Mercury in late March 1975. Barely enough trajectory correction fuel remains to permit the third trip but controllers at NASA's Jet Propulsion Laboratory hope to guide the interplanetary explorer back over Mercury's night side to provide more data on the planet's suspected magnetic field.

Just as the Apollo missions did not answer all our questions about the moon, future flights to Mercury, Mars and beyond will only add pieces to the giant cosmic jigsaw puzzle. We are still a long, long way from the answer to the big question: How did it all happen, and why are we a part of it?

(For additional information on Mercury and Mariner 10 see the June 1974 and September 1974 issues of *ASTRONOMY*.)

Is Gravity Weakening?

Gravity is the great structural force of the universe. Planets orbiting the sun, stars revolving around our galaxy's center, and perhaps even galactic clusters are governed by its universal pull.

Since Newton deduced the universality of this force, it has been generally assumed that there is a certain immutability about it. Given two bodies, Newton's equation says that if their masses and the distance between them remain constant, the gravitational force between them will be the same for eons. The point is so obvious that it is seldom stressed in lectures on the subject.

But it is just this point that is a major matter of contention among modern cosmologists.

Several modern cosmological theories — including those of Dirac, Brans and

Dicke, and Hoyle and Narlikar — called for a mutable gravity. They say that Newton's universal gravitational constant is not a constant but a variable that changes with time — that it actually declines.

Einstein, when formulating his general relativity theory — which is the most widely respected modern cosmology — followed Newton and opted for immutable gravity.

Now after some years of theoretical debate, the question is becoming one of observational astronomy. Thomas C. Van Flandern of the United States Naval Observatory says he has evidence that the strength of gravity is declining by one part in 10 billion per year. His information is derived from the motions of the moon.

If gravity declines in strength,

the orbits of astronomical bodies will get larger and their periods longer. In the past, it would have been difficult if not impossible to measure such a change since standards for measuring time depended on the motions of astronomical bodies, and looking for changes in those motions would have been like trying to compare something with itself.

For the past 19 years we have had atomic time standards, which are independent of astronomical motions. This made it possible for Van Flandern to study occultations of stars by the moon during that period, and from these observations deduce a change in the moon's motion that goes beyond a general slowing down expected as a result of tidal interactions between Earth and the moon. The best hypothesis to explain the excess, he says, is that gravity gradually declines in strength. The numerical amount is about that which is called for by the Hoyle/Narlikar theory, but larger than that expected by the Brans/Dicke theory.

In support of his contention Van Flandern cites a long standing discrepancy between observations of the deceleration of Earth's rotation and what theory would predict. Declining gravity would explain the anomaly. He also points to the apparent excess of wide orbit binary star systems over those with small orbits. If gravity weakens with time, binary systems will evolve toward wider and wider orbits.

There are those who complain that it is too early in the game to draw such a "solar system shaking" conclusion. At least one of them has sharply questioned the statistical significance of Van Flandern's numbers, pointing out that the whole question does not depend on his observations alone. Independent checks are under way including the lunar ranging experiment with laser light (LURE), radar tracking of the planet Mercury and certain laboratory experiments. Further results are eagerly awaited.

If gravity is weakening, that may provide the key to one of the mysteries of geophysics. It appears that the floors of the oceans are spreading apart along certain midoceanic ridges and that the continents are embedded in large crustal plates that keep moving around. If gravity weakens, as Van Flandern points out, the globe of our planet will expand (because of the lessening of Earth's self-gravitation) and the surface increase in area. Spreading of the surface at some point or points must necessarily follow.

Scientists Baffled By Strange Double Star

Two midget stars, orbiting around one another at a dizzying 450,000 m.p.h., have astronomers scrambling to their radio telescopes and computers in an attempt to answer some baffling questions. According to current theory, two stars as close together as this pair should not exist.

Separated by less than a million miles (about the width of the sun), the stars have to whirl around like the ends of a giant celestial baton to keep from spiraling into each other. They each complete a circuit in 7-1/2 hours. Both this rapid revolution period and the nearness of the two stars are astronomical "firsts".

"One of the stars is a pulsar," says the University of Massachusetts' Joe Taylor, a co-discoverer of the stellar duo. Using the 1,000 foot radio telescope at Aricebo, Puerto Rico, Taylor and R.A. Hulse detected radio surges from the pulsar 17 times per second — the second fastest rate for any known pulsar.

All of the 140 known pulsars are believed to be 10 mile wide neutron stars whose intense magnetic fields focus pulses of energy in our direction each time the star spins on its axis. That means this particular neutron star rotates 17 times each second. According to current theory, neutron stars are the remnants of the cores of giant stars that destroyed themselves in monstrous supernova explosions.

The second star of the pair is, as yet, unobserved but reveals itself by its effect on the motion of the pulsar. Preliminary estimates place the pair 1,500 light-years away.

The two astronomers have deduced that the invisible companion is either a neutron star that is not also a pulsar — and hence unobservable — or a white dwarf star. White dwarfs are about the size of Earth but contain as much matter as the sun. The 10 mile wide neutron stars also contain an equivalent of one solar mass making them the most compact visible objects known. A teaspoonful of matter from a neutron star would weigh 100 million tons on Earth.

There is also the possibility that the invisible companion is a black hole — a bizarre gravitational whirlpool where gravity overcomes all other forces and sucks up even speedy beams of light, swallowing them forever.

Whatever the companion's nature, there is an unexplainable aspect to both of these strange cosmic twins. Black holes, pulsars, neutron stars and white dwarfs are all cadavers of dead stars of huge dimensions. How did these two stars get so close together if they each had to come from stars larger than the sun? How did one survive the supernova explosion required to create the other?

It's just one more puzzle whose resolution may shake our present ideas of the evolution and death of stars.

Soviets Claim Universe Holds Billions of Black Holes

The Milky Way galaxy and the countless other galaxies of stars that populate the universe may contain billions more dead stars and mysterious black holes than previously believed. This startling announcement came from three Russian astronomers who claim that the masses of galaxies, like the Milky Way, have been underestimated by drastic amounts.

The Milky Way galaxy is a gigantic wheel shaped collection of stars over 100,000 light-years from edge to edge. Our sun is one of 150 billion stars that populate this vast system. There are billions of known galaxies of various shapes and sizes sprinkled throughout the void to form the known universe.

Now, according to Jean Einasto, Ants Kaasik and Enn Saar of the Struve Astrophysical Observatory in Estonia, there is much more material in galaxies than just billions of stars. They came to this conclusion after observing the orbits of some bright stars around the nucleus of our own and other galaxies. They found that the observed orbits are only possible if there are tremendous amounts of invisible mass within galaxies.

Since the material required for the discrepancy cannot be observed, it must be in the form of faint but massive objects. Only one type of known object seems capable of satisfying the dilemma. This is the mysterious and ominous black hole — a gravitational whirlpool that can sweep incoming matter out of this universe. It is a one-way trap formed by tremendous pressure during the collapse of a large star.

There is no upper limit to the amount of material that a black hole can absorb and thereby increase in mass. So they are the prime candidates for accounting for the missing mass that the three astronomers have said must be there.

The fascinating aspect of these observations is that it solves another cosmological dilemma that has plagued astronomers for years. The universe has been expanding at a tremendous velocity to reach its present diameter of about 20 billion light-years. The expansion began 10 to 13 billion years ago according to currently accepted theories. Those theories also predict an end to the expansion and a subsequent contraction and collapse of the universe to a point of re-creation of a new universe. This oscillating universe theory provides an infinite time span

for the creation and destruction of universes.

The theory has very wide appeal but the observed numbers of stars and other objects in the universe were not sufficiently massive to attract each other enough to halt the headlong expansion that is now taking place.

So this new discovery, if substantiated by other astronomers, may provide the missing mass in the form of black holes, and thus link the most

favorable theories for the origin and destiny of the universe. But it also may supply the ominous implication that black holes are rampant in the universe.

Even so, billions of black holes are probably nothing to get worried about. The collision of a star and its system of planets with a black hole is probably an exceedingly rare event — even if black holes are as common or more common than stars. ☛

Very Peculiar Galaxy



Lick Observatory Photograph

This peculiar object, discovered in 1950 by Arthur Hoag, appears to be a halo surrounding a diffuse nucleus. Hoag remarked that although it looks like a planetary nebula (a ring of gas puffed off from a star) its color was not typical of such nebulae. Recently three astronomers studied this object more closely and agreed that it is a distant galaxy located about 500 million light-years from us. The core is about 15,000 light-years across and the ring has inner and outer diameters of 70,000 and 110,000 light-years. The object is not readily seen in small telescopes, having a magnitude of only 15. Other galaxies like it are known although they are very rare. The ring is apparently shining because it consists of stars. But where this type of galaxy can fit into current theories of galaxy formation is totally mysterious. It is possible that the ring is actually an image of a very distant background galaxy enlarged as the result of a gravitational "lens" effect produced by the galaxy which is the nucleus of Hoag's object. But this is thought to be unlikely, because for this to occur the object at the nucleus would have to be 100 times as massive as the whole Milky Way galaxy, and the light from the nucleus does not show the spectral characteristics consistent with such a mass. Clearly Hoag's galaxy is a very strange object. Located in the constellation Serpens, it apparently is not a member of any cluster of galaxies making it even more abnormal.

Hot Gas Fills the Galaxy

Some interstellar gas is at least 100 times hotter than previously thought and probably fills much of the "empty" space in the galaxy, according to two Princeton University astronomers. Using the 32 inch ultraviolet telescope aboard the orbiting Copernicus satellite, Edward B. Jenkins and Donald G. York determined, from recent spectroscopic observations and data collected during an earlier survey of hot, very luminous stars, that there is a large quantity of oxygen VI between Earth and the stars. (Oxygen VI is an oxygen ion in which each atom has lost five electrons.)

"The existence of such an ion," Jenkins reported at a recent meeting at Harvard University, "signals the presence of a gas consisting of mostly free electrons and protons in a form similar to the material in the sun's corona — but which, from our observations, proved to be too widespread to be related to the stars themselves."

From these observations, Jenkins and York concluded that the temperature of the oxygen VI gas would be between 360,000 and 3,600,000 degrees Fahrenheit—since only at such extreme temperatures could there be enough energy in randomly moving electrons

to knock five electrons off each oxygen atom in successive collisions. (Oxygen has eight electrons in its normal state.)

"This low density gas," Jenkins said, "probably fills from 10 to 90 percent of the space between the stars."

The existence of so much of this superheated gas appears to be related to supernovae, those monstrous explosions that signal the sudden death of a star. The gas represents material left over long after these supernovae outbursts. Scientists estimate that one such supernovae occurs about every 30 years in our galaxy. The Jenkins-York discovery of the large quantity of hot gas could be consistent with this estimate, but it would depend on the amount of energy in each explosion — as well as on the density and structure of interstellar material in the vicinity of each supernova.

Prior to this report, astronomers had been postulating that interstellar material consists of cold hydrogen clouds with temperatures around -280 degrees with warmer regions — mainly the nebulae around the stars — composed of free protons and electrons with temperatures of about 17,000 degrees. Density estimates for both of these gases range from one particle per cubic inch to at least 150,000 particles per cubic inch.

As long as 18 years ago, Lyman Spitzer, chairman of Princeton's astrophysics department and principal investigator for the Copernicus space telescope, suggested the possible existence of the hot gas discovered by Jenkins and York through the use of the Copernicus instrument. Spitzer maintained that the outer regions of our galaxy might also contain a gas with a temperature of about two million degrees and a density of one particle per 30 cubic inches. Spitzer contended that a hot gas was necessary in order to keep the cold clouds, known to exist in outer galactic regions, from dissipating under their own pressure.

Observation of oxygen VI requires a special telescope well above the obscuring blanket of Earth's atmosphere. At the satellite's altitude of 425 miles, the orbiting telescope can detect radiation at wavelengths near 1,035 angstroms — about 1/5 the wavelength of visible light. Interstellar atoms such as oxygen VI leave characteristic dips in the spectra of hot stars, because the starlight is scattered by the atoms at specific wavelengths unique to each atom or ion. In the Copernicus satellite, the spectrum of the star is obtained by reflecting the starlight off a grating

Largest Radio Scope Gets Big Power Boost

The world's largest telescope has now been refurbished with a shimmering aluminum surface that makes it capable of receiving signals from other intelligent civilizations anywhere in the Milky Way galaxy. The 1,000 foot wide radar-radio telescope, operated by Cornell University, is located near Arecibo, Puerto Rico.

Now ready to open new windows to the universe, the telescope will probe within the orbit of our moon for possible other, tiny satellites of Earth. It will pierce the clouds of Venus — 50 miles thick — and return photograph-like images of the surface of Earth's sister planet. The telescope's radar will also make fairly detailed pictures of Mercury and Mars, reveal the nature of the surfaces of 50 or more asteroids, map the four major satellites of Jupiter, and glean new information on Saturn's rings.

The telescope may detect as many as 100,000 cosmic radio sources never before heard, including the rather faint emissions coming from the edge of the observable universe. And of equal importance, the telescope will be used to search for radio transmissions from other intelligent life in space.

The Arecibo telescope is a device for exploring the universe through the radio part of the spectrum. Radio signals, like light, are emitted by stars and galaxies, and can be bounced off the surfaces of planets in radar experiments. Unlike light, they can be observed right through clouds or dust with equal strength in daytime and nighttime.

Radio energy from some sources requires more than 10 billion years to reach Earth. Celestial radio signals are so faint that all the energy collect-

ed in the 40 year history of radio astronomy is about equal to that released when a few snowflakes fall on the ground.

The enormous dish, which collects the radio waves, fills a natural bowl 1,000 feet in diameter which was formed by the collapse of huge limestone caves. High over the dish, 50 stories in the air, the receiving and transmitting equipment — all 600 tons of it — hangs from three concrete support towers in the surrounding hills.

The three year, \$8.8 million upgrading project saw the old wire mesh of the telescope's reflector bowl ripped off and replaced by 38,778 individual aluminum panels — each 40 by 80 inches in size. Each panel is located in position so that the giant disk has an overall curvature accurate to within 1/8 of an inch. This accuracy is ensured by a laser-measuring device which hangs on the instrument platform, 50 stories above the aluminum dish.

In addition to the resurfacing, a powerful new radar system was added to the observatory's existing transmitters. The 450,000 watt output of this new transmitter, when concentrated into a narrow beam by the reflector, has an effective power 100 times greater than the total electric power production of all the generating plants in the world. This is the strongest signal now leaving Earth. The beacon is a manifestation of mankind powerful enough to be detected by instruments similar to the Arecibo telescope located anywhere in the Milky Way. Indeed, to the radio eyes of creatures of far distant stars, the Arecibo telescope would gleam 10 billion times more brightly than our sun.

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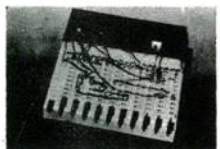
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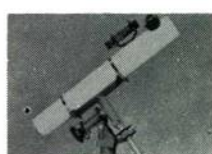
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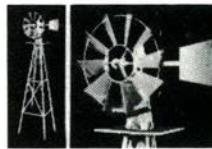
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